STATE LIBRARY OF PENNSYLVANIA
3 0144 00541419 8

PZ 3
G48

Digitized by the Internet Archive
in 2016 with funding from
This project is made possible by a grant from the Institute of Museum and Library Services as administered by the Pennsylvania Department of Education through the Office of Commonwealth Libraries

https://archive.org/details/stratigraphypale00el0

APR 27 1966

General Geology Report G 48

1965

Stratigraphy and Paleontology of the Mahantango Formation in South-central Pennsylvania

Robert L. Ellison

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF INTERNAL AFFAIRS
Genevieve Blatt, Secretary

BUREAU OF
TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

PENNSYLVANIA STATE LIBRARY
DOCUMENTS SECTION

BULLETIN G 48

Stratigraphy and Paleontology of the Mahantango Formation in South-central Pennsylvania

by Robert L. Ellison
Cooperating Geologist
Pa. Geological Survey

PENNSYLVANIA GEOLOGICAL SURVEY
FOURTH SERIES
HARRISBURG

1965

Copyrighted 1965
by the
Commonwealth of Pennsylvania
Quotations from this book may be published if credit is given
the Pennsylvania Geological Survey

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PURCHASED FROM
DIVISION OF DOCUMENTS, BUREAU OF PUBLICATIONS
10TH AND MARKET STREETS, HARRISBURG, PA. 17125

CONTENTS

	Page
Introduction	1
Statement of the problem	1
Acknowledgments	1
Geographic setting	2
Summary of previous work	3
General statement concerning the Mahantango Formation	3
Hamilton Group of New York	5
Hamilton Group of Pennsylvania	7
Stratigraphy	10
Mahantango Formation of Perry and adjacent counties	10
General statement concerning stratigraphy	10
Lower shale member	11
Montebello Sandstone Member	14
Upper shale member	18
Mahantango Formation of Bedford and Fulton Counties	21
General statement concerning stratigraphy	21
Gander Run Shale Member	22
Chaneysville Siltstone Member	23
Frame Shale Member	25
Mahantango Formation of Huntingdon and Blair Counties	26
General statement concerning stratigraphy	26
Gander Run Shale Member	28
Backbone Ridge Siltstone Member	29
Crooked Creek Shale Member	30
Donation Siltstone Member	30
Frame Shale Member	31
Summary and correlation of the Mahantango Formation	32
Correlation of the Mahantango Formation of south-central Pennsylvania	33
Tully Limestone Member of the Harrell Formation and its relationships with the Mahantango Formation of south-central Pennsylvania	37
Correlation of the Mahantango Formation of south-central Pennsylvania with formations of the Hamilton Group of New York	39
History of sedimentation	42
Summary and Conclusions	46
Systematic paleontology	48
Introduction	48
Descriptions	48
Phylum Coelenterata	48

CONTENTS—Continued

	Page
Phylum Bryozoa	49
Phylum Brachiopoda	60
Phylum Mollusca	115
Phylum Arthropoda	157
Phylum Echinodermata	171
Selected bibliography	171
Appendix—Description of the sections	179
Introduction	179
Sections in Perry and adjacent counties	179
Section 1.—Rockville	179
Section 2.—Marysville	186
Section 3.—Dromgold	191
Section 4.—Falling Springs	195
Section 5.—New Bloomfield	198
Section 6.—Amity Hall	204
Section 7.—Girtys Notch	209
Section 8.—Millerstown	215
Section 9.—Mahantango Creek	219
Sections in Bedford and Fulton Counties	223
Section 10.—Websters Mills	223
Section 11.—Chaneysville	230
Section 12.—Elk Lick Creek	233
Section 13.—Turnpike at Everett	235
Section 14.—Bedford	239
Section 15.—Fishertown	242
Section 16.—Huntingdon	245
Section 17.—Martin Gap	255
Section 18.—Newry	258
Fossil plates	263

ILLUSTRATIONS

FIGURES

Figure 1.	Location of the study area and described sections in south-central Pennsylvania	2
2.	Present status of classification and nomenclature of the Hamilton Group of New York and Pennsylvania	3
3.	Evolution of the classification and nomenclature of the Hamilton Group of New York	4

ILLUSTRATIONS—Continued

		Page
4.	Evolution of the classification and nomenclature of the Hamilton Group of Pennsylvania	6
5.	Tentative correlation of the faunal zones of the Mahantango Formation as described in the three areas of study	34
6.	Correlation of the Hamilton Group of south-central Pennsylvania and eastern New York	39
7.	Lines of evidence used in correlating the Hamilton Group of south-central Pennsylvania and eastern New York	40
8.	Summary of the stratigraphic relations of the members of the Mahantango Formation	47

PLATES

Plate	1.	Stratigraphic relationships of the Mahantango Formation in Perry and adjacent counties	*in pocket*
	2.	Stratigraphic relationships of the Mahantango Formation in Bedford and Fulton Counties	*in pocket*
	3.	Stratigraphic relationships of the Mahantango Formation in south-central Pennsylvania	*in pocket*
	4-19.	Illustrations of fossils	*following page* 263

TABLES

Table	1.	Petrographic features of samples collected from sandstones and siltstones of the Mahantango Formation	12
	2.	Assemblage zones of the Mahantango Formation of Perry and adjacent counties	15
	3.	Assemblage zones of the Mahantango Formation of Bedford and Fulton Counties	21
	4.	Assemblages of the Mahantango Formation at Huntingdon	28
	5.	Depositional loci of stratigraphic units of the Mahantango Formation	44
	6.	Lists of Mahantango Formation fossil species	50
	7.	Measurements of new brachiopod species from the Mahantango Formation of south-central Pennsylvania	82

STRATIGRAPHY AND PALEONTOLOGY OF THE MAHANTANGO FORMATION IN SOUTH-CENTRAL PENNSYLVANIA

by

Robert L. Ellison

INTRODUCTION

STATEMENT OF THE PROBLEM

The faunas of the profusely fossiliferous Mahantango Formation in south-central Pennsylvania have received less systematic attention than they merit, partly, it appears, because the fossil specimens tend to be imperfectly preserved, and partly because the species have been assumed to be identical with those of New York. Furthermore, relationships between stratigraphic units within the Mahantango Formation, as well as between the Mahantango Formation in south-central Pennsylvania and its Hamilton equivalents in New York, are understood only in the most general sense.

The present study is an investigation of the Mahantango Formation in south-central Pennsylvania with emphasis on the systematic and stratigraphic paleontology. Such a paleontological study, coupled with detailed section measurements and descriptions, should be valuable in understanding better the stratigraphic relationships of units within the Mahantango Formation as well as the relationships between the Mahantango and contiguous formations.

Field work commenced in the summer of 1955. Portions of the summers of 1956 through 1958 as well as other shorter periods have been devoted to measuring and describing sections and collecting fossil material.

ACKNOWLEDGMENTS

Several individuals have contributed significantly to the realization of this study. Throughout the course of the investigation, Dr. Frank M. Swartz, of The Pennsylvania State University, was the adviser, and his suggestions and counsel are greatly appreciated. My indebtedness to my wife, who, in addition to assisting in the preliminary typing, worked with me in the field, in the summers of 1956 and 1957, also is acknowledged. Dr. G. A. Cooper, of the U. S. National Museum kindly permitted me to examine many fossil specimens in the Museum. Appreciation is extended also to Dr. W. A. Oliver, Jr., of the U. S. Geological Survey, for his identification of coral specimens collected from the

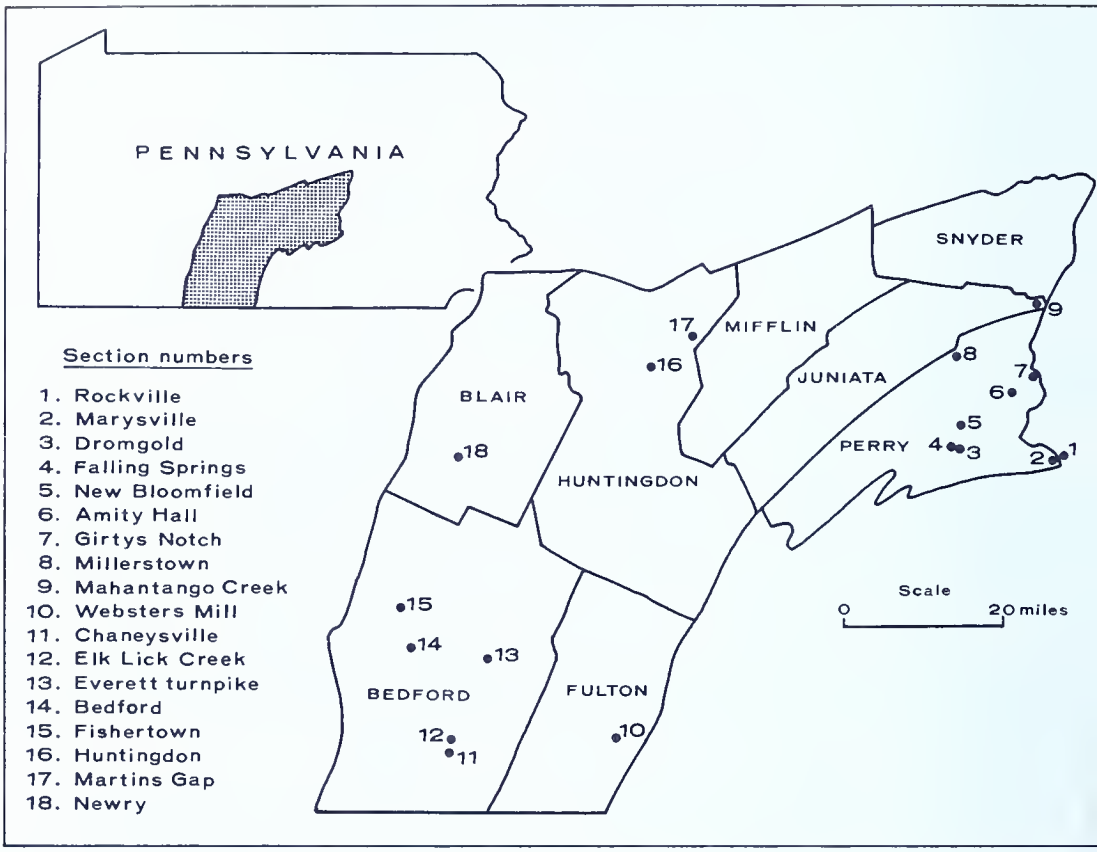


Figure 1. Location of the study area and described sections in south-central Pennsylvania.

Mahantango Formation; to Dr. William Spackman, of The Pennsylvania State University, for his identification of *Callixylon;* and to Dr. M. L. Keith, of The Pennsylvania State University, for his analyses of trace elements in sandstones of the Mahantango Formation. Finally, appreciation is extended to Dr. Donald Hoskins, Richard Conlin, and Lawrence Frakes, whose comments and suggestions contributed significantly to the improvement of this report.

Financial support during the Spring of 1958 was provided by the Experiment Station of the College of Mineral Industries of The Pennsylvania State University, and a grant-in-aid from the American Association of Petroleum Geologists covered some of the expenses incurred in the field and laboratory. The Research Committee of the University of Virginia provided funds to defray the cost of typing the manuscript.

GEOGRAPHIC SETTING

The area of study is that part of the Ridge and Valley Province lying between the Susquehanna River and the Allegheny Front on the east

and west respectively, and between the 40°45′ parallel of latitude on the north and the Pennsylvania-Maryland line on the south (see fig. 1).

The field investigations of the Mahantango Formation have been concentrated in three areas, namely (see fig. 1) in (1) Perry County and adjacent portions of Dauphin, Juniata, and Snyder Counties, where the Montebello Sandstone Member of the Mahantango Formation is best developed; (2) Bedford and Fulton Counties, where the Mahantango Formation consists largely of siltstone and sandy shale, and has close affinities to the "Hamilton Member" of the "Romney Formation" in Maryland and Virginia; and (3) Huntingdon County, where the shaly development of the Mahantango Formation is well expressed.

SUMMARY OF PREVIOUS WORK

General Statement Concerning the Mahantango Formation

In Pennsylvania, the Middle Devonian Hamilton Group is composed of the Marcellus and Mahantango Formations. The term Mahantango Formation was introduced by Willard (1935a) to refer to the strata between the black shales of the Marcellus Formation and the rocks of the "Portage" Group in Pennsylvania where the formations of the Hamilton Group as described by Cooper (1930, 1933) for New York are not readily recognizable. Classifications used by most recent workers for stratigraphic units of the Hamilton Group of New York and Pennsylvania are shown in figure 2.

	Pennsylvania (Willard, 1939)		*New York (Cooper, et. al., 1942)*	
Upper Devonian	Fort Littletan Formation		Genessee Group	Enfield shale
				Ithaca shale
				Carnell shale and sandstone
				Sherburne sandstone
	Rush Fm	Burket Member		Genesea shale
		Tully Member	Tully Formation	
Middle Devonian	Hamilton Group	Mahantanga Formation	Hamilton Group	Mascaw shale
				Ludlawville shale
				Skaneateles shale
		Marcellus Formation		Marcellus shale
	Onandaga Group		Onandaga limestone	

Figure 2. Present status of the classification and nomenclature of the Hamilton Group of New York and Pennsylvania.

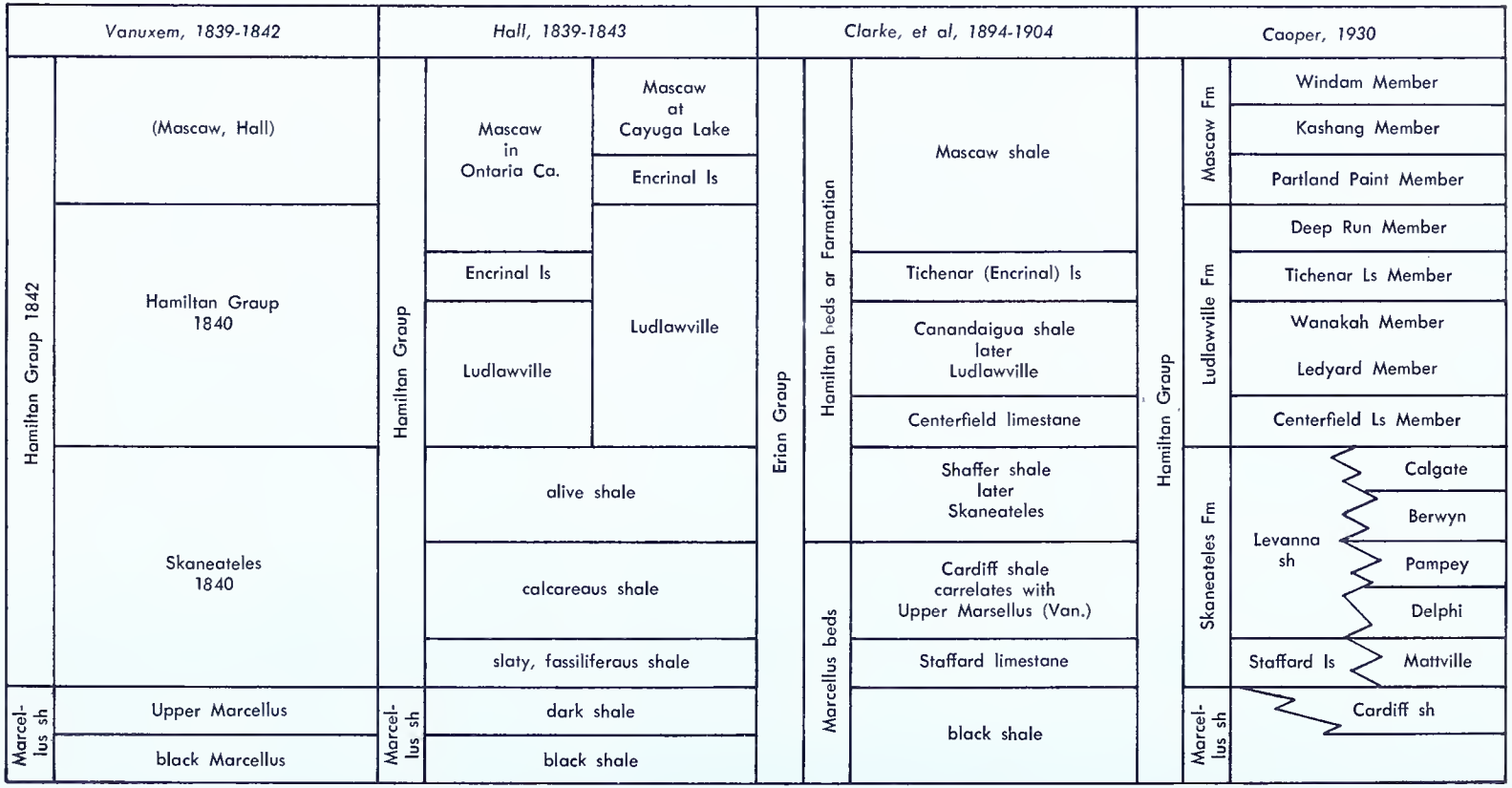


Figure 3. Evolution of the classificotion ond nomenclature of the Homilton Group of New York.

Inasmuch as the early work on the Middle Devonian in the Appalachians was done in New York, and also because the sequence there is relatively well understood, the stratigraphic terminology for the Hamilton in the Appalachian Region is largely that of New York. For these reasons, the Hamilton Group of New York is considered here before attention is directed to the Hamilton Group of Pennsylvania.

Hamilton Group of New York

The Hamilton Group of New York is one of the most intensively studied and best understood stratigraphic sequence in the Appalachians. Since publication of the volumes of Vanuxem and Hall on work done during the first geological survey of the State, the classification and nomenclature of the Hamilton Group has evolved considerably (see fig. 3). More than 100 years ago, Vanuxem (1840, p. 380) recognized a three-fold division in the rocks between the Marcellus black shales and the Tully limestone. These three units were termed, in ascending order, the Skaneateles shales, the Hamilton Group, and the Moscow shales. The term "Hamilton Group" was expanded later by Vanuxem (1842) to include all of the rocks from the base of the Skaneateles shale to the base of the Tully limestone. Prosser (1888) applied the term "Hamilton Formation" to the same sequence between the Marcellus and the Tully; this remained the established definition until publication of Cooper's work in 1930. Cooper (1930) elevated the term "Hamilton" to the rank of a group to include the Marcellus as well as the Skaneateles, Ludlowville, and Moscow Formations. At the present time, Cooper's classification is used by the U. S. Geological Survey and the New York Geological Survey. It should be noted here that, although the Skaneateles, Ludlowville, and Moscow Formations are somewhat distinct lithologically and faunally, they are differentiated primarily on the basis of several thin beds of limestone that serve as boundaries between the formations throughout a large part of the State. These three limestone members —in ascending order, the Stafford, Centerfield, and Portland Point Members—in addition to serving as formational markers, also are treated as time planes by Cooper. The presence of the limestones marker beds is one of the most important single stratigraphic features of the Hamilton Group in New York.

As described by Cooper (1933, p. 537), the Hamilton Group in New York is a "huge wedge of clastic sediments thickening rapidly eastward." Toward the east, the Hamilton Group is represented by nearly 2,500 feet of arenaceous shale, sandstone, and cross-bedded sandstone, and is divided in ascending order into the Berne Shale Member, Otsego Shale Member, Panther Mountain Shale and Sandstone Member, and Moscow

<table>
<tr><th>Rogers, 1858</th><th>White, 1885</th><th>Claypole, 1885</th><th colspan="4">Willard, 1939</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Bedford Co.</td><td>Perry Co.</td><td>Monroe Co.</td></tr>
<tr><td rowspan="6">Cadent sholes</td><td>Hamilton upper sholes</td><td>Homilton upper shole</td><td rowspan="6">Hamilton Group</td><td rowspan="5">Mahantango Formation</td><td>Frame Shale Member</td><td rowspan="5">Montebello sandstone facies</td><td rowspan="3">Ludlowville "facies"</td></tr>
<tr><td>Hamilton upper ss</td><td rowspan="3">Hamilton (Montebello) sandstone</td><td rowspan="2">Chaneysville Sandstone Member</td></tr>
<tr><td>Hamilton middle sholes</td></tr>
<tr><td>Homilton lower ss</td><td rowspan="3">Gander Run Shale Member</td></tr>
<tr><td>Hamilton lower shales</td><td rowspan="3">Hamilton lower shale</td><td rowspan="2">Skaneateles "facies"</td></tr>
<tr><td>Marcellus gray shales</td></tr>
<tr><td>Cadent Lower Black Slate</td><td>Marcellus black slates</td><td colspan="3">Marcellus Formation</td></tr>
</table>

Figure 4. Evolution of the classification and nomencloture of the Hamilton Group of Pennsylvania.

Formation. In western New York, the Hamilton Group of Cooper is represented by less than 500 feet of shale and is divided, in ascending order, into the Marcellus, Skaneateles, Ludlowville, and Moscow Formations.

In discussing his correlation of the Hamilton Formations, Cooper relies heavily upon two particular zones: (1) the *Fimbrispirifer divaricatus ("Spirifer divaricatus")* Zone, used for correlating the Centerfield Member and its equivalents; and (2) the *Pustulatia pustulosa-"Spirifer" tullius ("Vitulina-Spirifer tullius")* Zone, which is in the upper part of the Moscow Formation. Cooper regards the westward disappearance of the *Pustulatia pustulosa-"Spirifer" tullius ("Vitulina-Spirifer tullius")* Zone as evidence of an unconformable contact between the Hamilton Group and the overlying Tully limestone.

The concept of recurrent faunas attendant with recurrent facies, as developed by H. S. Williams (1903), and expanded by later workers, is essential in interpreting the distribution of species within the Hamilton Group. According to Williams, the Hamilton fauna is chiefly a fauna of eastern and central New York and is dominated by the brachiopod *Tropidoleptus carinatus.* The Hamilton fauna of eastern New York contains numerous species of pelecypods that tend to be replaced by species of brachiopods toward the west. In contrast, the Marcellus fauna as described by Williams is a fauna of central and western New York and is dominated by the brachiopod *Leiorhynchus limitare.*

Two features of the Hamilton Group in New York should be kept in mind when considering stratigraphic relationships with rocks in Pennsylvania: (1) the exposures all occur along one outcrop belt striking east-west and, therefore, little or no information is available concerning the distribution of lithofacies and biofacies in a north-south direction; and (2) formations and members as defined and extended by Cooper are intended to represent time-rock units.

Hamilton Group of Pennsylvania

In Pennsylvania, the classification of rocks of the Hamilton Group is not as well ordered, nor is the stratigraphy as well understood as in New York (see fig. 4). Nearly 20 years after Vanuxem's original work on the Hamilton Group in New York was published, H. D. Rogers published the Geology of Pennsylvania. The Cadent Series of Rogers (1858, vol. 1, p. 108) includes the Cadent Lower Black Slate, which is equivalent to the Marcellus slate of New York; the Cadent Shales, which are equivalent to the Hamilton Group of New York; and the Cadent Upper Black Slate, which is equivalent to the Genessee slate of New York. The Cadent Shales are described by Rogers as fossiliferous shales with minor beds of sandstones, and measure 900 feet in thickness at Huntingdon.

The Second Geological Survey of Pennsylvania discarded the term "Cadent" and adopted the New York term "Hamilton" for the sequence of gray rocks between the black Marcellus shale and the Tully limestone.

In Northumberland County, White (1883, p. 79) described the following units within the Hamilton:

Olive shales	450 feet
Selinsgrove upper sandstone	202 feet
Olive shales	125 feet
Selinsgrove lower sandstone	5 feet
Shales	800 feet
Selinsgrove upper limestone	40 feet

White (1885, p. 105) also recognized the following units of the Hamilton Group in Huntingdon County:

Hamilton upper shales	250 feet
Hamilton upper sandstone	30 feet
Hamilton middle shales	225 feet
Hamilton lower sandstone	50 feet
Hamilton lower shales	75 feet
Marcellus gray shales	325 feet
Marcellus black slates	300 feet

White, however, does not go beyond suggesting that the lower sandstone of Huntingdon County may represent the Selinsgrove upper sandstone of Northumberland and the lower part of Claypole's Montebello sandstone in Perry County.

Claypole's subdivision of the Hamilton of Perry County is as follows (1885, p. 66):

Hamilton upper shale	200-300 feet
Hamilton Montebello sandstone	500-800 feet
Hamilton lower shale	400-500 feet

Claypole (1885, p. 67) named the Montebello sandstone from its fine exposures in Montebello Narrows in Perry County, where it consists of two sequences of sandstones separated by shale. According to Claypole, the tripartite nature of the Montebello sandstone is less obvious at Marysville than at Montebello Narrows. He further states that the Montebello sandstone becomes less sandy and thinner toward the northwest from Marysville in Perry County, and correlates the Montebello with the upper and lower sandstones of White in Huntingdon County. Within the "Hamilton upper shale" immediately overlying the Montebello, several units were recognized by Claypole (1885, p. 69). In descending order, these units are:

Fenestella shale	15 feet
Tropidoleptus shale	15 feet

Barren shale	200 feet
Paracyclas shale	2 feet
Montebello fossil ore	2 feet

In addition to introducing the term Mahantango Formation, Willard presented evidence to support tentative correlations of Hamilton units in Pennsylvania, especially eastern Pennsylvania, with units in New York as defined by Cooper. As originally described by Willard (1935, p. 205), the Mahantango Formation consists predominantly of "uniformly dark gray or brown, usually clayey or finely arenaceous shale to fine-grained, dark, shaly sandstone which may become platy or flaggy locally."

According to Willard, the Marcellus-Mahantango contact, wherever exposed, is gradational, but the upper contact of the Mahantango with the overlying Portage is abrupt, both lithologically and faunally. The introduction of *Hypothyridina venustula* and its associated fauna is considered diagnostic for the base of the Upper Devonian. Although *H. venustula* is usually found in the Tully limestone, Willard has reported it also from the Trimmers Rock Member of the Fort Littleton Formation in eastern Pennsylvania.

On the basis of faunal evidence, Willard has described "facies" of the Mahantango Formation in eastern Pennsylvania that have affinities with the Skaneateles, Ludlowville, and Moscow Formations of New York. The faunal criteria used by Willard (1939, p. 184) are as follows:

Skaneateles "facies"—abundant *Mediospirifer audaculus* and *Bembexia sulcomarginata; Tropidoleptus carinatus* and *Spinocyrtia granulosa* are common; this "facies" typically is deficient in mollusks and arthopods.

Ludlowville "facies"—abundant specimens of bryozoans, *Protoleptostrophia perplana*, and *Schuchertella variabilis*, as well as species of *"Chonetes"*, *"Spirifer"*, and *Camarotoechia;* other common species are *Pustulatia pustulosa, Rhipidomella leucosia, Tropidoleptus carinatus, Devonochonetes coronatus*, and *Delthyris sculptilis;* the Ludlowville "facies" typically contains numerous specimens of pelecypods, gastropods, and trilobites, particularly *Phacops rana.*

Moscow "facies"—the fauna is similar to that of the Ludlowville "facies", but with fewer specimens of *"Chonetes"*, mollusks, and bryozoans.

In central and southern Pennsylvania, the Skaneateles, Ludlowville, and Moscow "facies" are obscure and the Moscow "facies" generally is absent (Willard, 1939). According to Willard, the Mahanango Formation is partly replaced in Perry County by the Montebello sandstone which is presumed to represent the Skaneateles and Ludlowville "facies" of the eastern part of the State. Farther south, in Bedford County, Willard (1935c, p. 1279) defined the following three units within the Mahantango Formation, in ascending order: Gander Run Shale Member, Chaneysville Sandstone Member, and Frame Shale Member. However, the Chaneysville Sandstone Member, according to Willard, is

distinct from the Montebello sandstone of Perry County. Willard's summary of the Hamilton Group in Pennsylvania (1939, p. 200) is as follows:

> The Hamilton succession in eastern Pennsylvania is similar to that worked out by Cooper in central New York but the divisions are less clearly defined. Westward and southwestward across central Pennsylvania, the New York affinities and similarities grow obscure . . . in the Susquehanna Valley, the Moscow, Ludlowville, and Skaneateles equivalents are only roughly deliminated faunally. The same Montebello sandstone is long in use for the great mass of Hamilton sandstone in the lower Susquehanna and Juniata Valleys. Elsewhere, the monotonous succession of post-Marcellus shales broken only by thin sandstone lenses has been designated the Mahantango Formation.
>
> Still further to the southwest, the Hamilton Group is even less differentiated. Local divisions show in the Mahantango. Here, there seems good faunal reason for suspecting that no beds of Moscow age are present. Throughout, the Hamilton Group exhibits, despite its lithologic variations, a close faunal unity. Its major divisions above the Marcellus, when not lithologcally distinct, are differentiated, not upon the presence or absence of particular genera or species, but upon the relative abundance or the proportional distribution of the faunas among the several classes of invertebrates.

STRATIGRAPHY

MAHANTANGO FORMATION OF PERRY AND ADJACENT COUNTIES

General Statement Concerning Stratigraphy

Exposures of the Mahantango Formation in Perry County and adjacent parts of surrounding counties represent the most easterly phase of the formation considered in the present study. Willard (1935) named the Mahantango Formation from its exposure along the North Branch Mahantango Creek in Snyder County. In Perry County the Mahantango Formation averages approximately 1600 feet thick, some 300 feet thicker than in any other area studied. From Perry County the Mahantango thins toward the west and southwest.

Three members, corresponding to the three divisions of the Hamilton proposed by Claypole (1885), are recognized in the Perry County area. They are, in ascending order, the lower shale member; the Montebello Sandstone Member, named after exposures in Perry County; and the upper shale member. These three units are readily recognizable within this area, but precise determination of stratigraphic position within units, especially within the Montebello Sandstone Member, may be difficult.

Approximately 60 percent of the formation is sandstone, most of which is concentrated in the middle, Montebello Member.

The stratigraphic relationships of the Mahantango Formation of Perry County with the underlying Marcellus Formation and with the overlying Tully limestone, as well as the relationships of intraformational units of the Mahantango Formation as presently understood, are shown in Plate 1. In addition, the thicknesses of the members of the formation in the measured sections may be found in Appendix I, and the petrography has been summarized in table 1.

Lower Shale Member

In the present study, the lower shale member is equivalent with the Hamilton lower shale of Perry County (Claypole, 1885), which Willard (1939) included in the Montebello sandstone.

The thickness of the lower shale member is about 650 feet at the Falling Springs section whereas the thickness is only 140 feet at Rockville, but there the base is concealed. Willard and Cleaves (1933) reported Marcellus in the section at Rockville, but the author has not observed nor collected evidence to support such a conclusion.

The lower shale member in Perry County largely is silty shale. Sandstone and siltstone make up less than 10 percent of this member, but they are ubiquitous throughout Perry and Snyder Counties. Individual beds of sandstone and siltstone, where exposed, have sharp lower contacts and gradational upper contacts. Commonly cross-bedded and locally lenticular, the beds of sandstone are most likely not contiguous.

Where exposed, the contact between the lower shale member and the Marcellus black shale is gradational. In the section at Mahantango Creek, the lower 10 feet of gray shale of the Mahantango Formation includes intercalated laminae of black shale which are believed to reflect lateral interfingering of gray shale of the Mahantango Formation with black shale of the Marcellus Formation.

The contact between the lower shale member and the overlying Montebello Member also is gradational. At Mahantango Creek, the gradation is very marked. The 140-foot concealed interval that succeeds the lower 15 feet of sandstone assigned to the Montebello Member may be largely shale, and perhaps should be included in the lower shale member. The contact between the lower shale and the Montebello members is much more abrupt at Rockville in that the upper part of the lower shale lacks interbedded sandstone. The shale, however, does become sandier toward the base of the Montebello Member. The evidence, although somewhat limited, favors the interpretation that the lower part of the Montebello Member grades laterally into the lower shale member.

In Perry County, the lower shale member generally is unfossiliferous. Willard and Cleaves (1933, p. 772) reported *Protoleptostrophia per-*

TABLE 1. *Petrographic features of samples from sandstones and siltstones of the Mahantango Formation.*

Section, thin-section number, and member	*Percent textural elements*			*Quartz grains*			*Other minerals*	*Remarks*	*Rock type*
	Grains	*Matrix*	*Cement*	*Percent*	*Mean size, in mm*	*Shape*			
Rockville									
11-217 Montebello	50-60	40-50	.....	50-60	0.289	subangular, subrounded; subequant	partially sericitized phyllite and metaquartzite fragments form matrix; minor zircon, feldspar, biotite, opaques	.....	low rank graywacke
11-239 Montebello	90	5-10 sericite	5 silica, minor hematite	80-85	0.414	rounded to subangular; subequant	10% fragments of metaquartzite and phyllite; minor chert, zircon, microcline	.....	quartzose graywacke
11-475 Montebello	60	40 sericite	.....	60	0.217	angular to subangular; subequant	minor zircon, biotite, feldspar, chlorite, microcline, opaques	sericitized rock fragments and matrix grade imperceptibly	low rank graywacke
11-497 Montebello	70-75	25 sericite	5 silica	70-75	0.303	angular to subangular; elongate to subequant	5% metaquartzite fragments; less than 5% chert and igneous rock fragments	sericitized rock fragments and matrix grade imperceptibly	quartzose graywacke
11-717 Montebello	85-90	1	5-10 silica	70	0.730	rounded; subequant	20% metaquartzite fragments: 2% chert	abundant "strained" grains of quartz, some illitic quartz grains	quartzite
11-834 Montebello	95	1	5 silica	75	0.336	subrounded, subangular; subequant	20% metaquartzite fragments; minor chert, phyllite; rare feldspar	illitic grains of quartz	quartzite
Marysville									
6-93 Montebello	85-90	5 sericite	5-10 silica, minor calcite	75-80	0.338	rounded; subequant	15-20% metaquartzite fragments; less than 5% chert and phyllite	.....	quartzite
6-293 Montebello	90	1	5-10 silica	90	0.550	rounded; subequant	8% metaquartzite fragments; 2% chert, biotite, phyllite; minor interstitial sericite and hematite	illitic grains of quartz	quartzite
6-363 Montebello	80	0-20	0-20	70	0.286	subangular; subequant	10% metaquartzite and phyllite fragments; less than 2% feldspar; minor biotite, zircon, opaques	matrix and cement indistinguishable	low rank graywacke

6-500 Montebello	90-95	1 sericite	5-10 silica	75	1.543	well rounded; high sphericity	20% metaquartzite fragments; 3% siltstone fragments; 1% aphanitic igneous rock fragments; 1% phyllite and chert	illitic grains of quartz	quartzite
Falling Springs 16B-1246 Montebello	85	5-10 sericite	5-10 hematite	85	0.155	angular to subangular; subequant	minor zircon, feldspar, chlorite, sphene, opaques	hematite around grains; sericitized rock fragments comprise matrix	quartzose graywacke
Amity Hall 4-50 Montebello	90	minor sericite	10 silica, hematite	75	0.560	rounded to subrounded; subequant	20-25% metaquartzite fragments; 1% chert	.....	quartzite
4-60 Montebello	90-95	less than 5% sericite	5-10 silica	90	0.460	rounded; subequant	less than 10% metaquartzite fragments; 1% chert	.....	quartzite
4-417 Montebello	50-60	40-50 sericite	5 calcite	50-60	0.083	subrounded; subequant	minor feldspar	.....	low rank graywacke
4-607 Frame	90	less than 2% sericite	10 silica	75	0.245	suhangular; subequant	20-25% metaquartzite fragments; minor phyllite, chert, feldspar	illitic grains of quartz	quartzite
Girtys Notch 17-299 Montebello	95	0-5 sericite	0-5 hematite	75	0.229	suhrounded, subangular; subequant	15-20% metaquartzite fragments; minor phyllite and chert; rare biotite and feldspar	hematite around grains	quartzite
Huntingdon 1-358 Backbone Ridge	40	40	20 calcite	40	0.055	suhangular; elongate	20% calcite, 2% pyrite, minor feldspar	cross-laminated	low rank graywacke
1-BR-10 Backbone Ridge	50-60	?	40-50 calcite	50-60	0.034	suhangular	40-50% calcite, minor muscovite, biotite, pyrite	banded; calcite cement masks matrix	low rank graywacke
1-BR-25 Backbone Ridge	60	?	40 calcite	60	0.047	subangular; elongate	biotite	calcite cement masks matrix	low rank graywacke
1-BR-45 Backbone Ridge	40-50	10	50 calcite	40-50	0.060	subangular; clongate	2-3% pyrite; minor muscovite and zircon	cross-laminated; calcite cement masks matrix	low rank graywacke
1-D-20 Donation	30-40	60-70	.....	30-40	0.046	.....	chiefly micaceous (sericitic?) matrix	dark, lenticular patches	low rank graywacke
1-D-50 Donation	50	25	25 calcite hematite	50	0.058	subangular; elongate	muscovite, biotite, shell fragments	laminated; grains oriented	low rank graywacke
1-N-6 Frame	40-50	50-60	.....	40-50	0.085	subangular; subequant	zircon, chlorite, hematite, tourmaline, hiotite, shell fragments	.....	low rank graywacke

plana, Devonochonetes coronatus, Rhipidomella sp., *Tropidoleptus carinatus,* and *Spinocyrtia granulosus* from the Fort Hunter Sandstone (Willard, 1939, p. 138) in the section at Rockville. The author found *Lingula?* sp. and *Nuculites* cf. *N. triqueter* from sandy beds in the shale judged to be above the Fort Hunter.

Montebello Sandstone Member

Approximately 60 percent of the Mahantango Formation in Perry County is sandstone, nearly all confined to the Montebello Sandstone Member. The Montebello sandstone is topographically the most prominent member of the Mahantango Formation, and forms the backbone of conspicuous ridges throughout south-central Pennsylvania. Although its greatest development is in Perry County, the Montebello Member as a recognizable unit extends northward at least as far as the vicinity of Selinsgrove Junction in Northumberland County, as well as northwestward at least into Juniata County.

From its maximum development in central Perry County, the Montebello Member thins toward the north and east. This may be seen from the stratigraphic diagram (Plate 1). The Montebello sandstone attains its maximum measured thickness of over 1000 feet at the Dromgold section. At the eastern margin of Perry County, the Montebello Member, at Marysville and Rockville, is approximately 800 feet thick. In the extreme northern part of Perry County, at Millerstown, the Montebello Member is nearly 650 feet thick. Still farther north, in the Mahantango Creek section, in Snyder County, the Montebello Member has thinned to less than 450 feet.

Petrographic studies of selected portions of the Montebello Sandstone Member have shown that the rocks range in composition from low rank graywackes to quartzites (table 1). Rock fragment grains of metaquartzite, composed of numerous quartz grains with interlocking, serrated boundaries, are common in the quartzites and quartzose graywackes, forming nearly 25 percent of the grains in some specimens. Silica cement, appearing as optically continuous silica overgrowths on quartz grains, forms about 10 percent of the rock in thin-sections of quartzite. In the specimens studied, quartzites occur only as medium-grained to coarse-grained sandstones, and most, but not all graywackes are siltstones or fine-grained sandstones. In addition to this general relationship between composition and grain size, an association exists between bedding character and grain size; fine- to medium-grained sandstone rarely is evenly bedded, whereas siltstone commonly is evenly bedded.

Lithologic units described at any one section commonly are local, but, fortunately, a few conglomeratic and shaly beds persist over wide areas. For example, distinctive sequences of beds described in the sec-

tion at Rockville commonly cannot be traced to the section at Marysville, only a mile away. In some places where the beds are nearly vertical, beds described at the base of the exposure are not present at the top of the same exposure. A striking example of this phenomenon is provided by a cross-bedded sandstone, about 400 feet above the base of the section at Marysville, that has removed at least 10 feet of the underlying beds by scour and fill at its thickest point, and removed little or none of the underlying beds at the margins of the scoured channel.

The Montebello sandstone is divisible into three major units: a lower sandstone, a middle shale, and an upper sandstone. These subdivisions were recognized by Claypole (1885) and by Willard (1939). At Rockville and Marysville a second unit of shale and a third unit of sandstone are present. Four faunal zones in the Montebello Member are traceable throughout Perry County, as shown in table 2. These faunal zones have been established, in part, on the basis of relative abundance of species, and, in part, on the basis of certain restricted species.

In the Rockville and Marysville sections, the lower unit of sandstone is itself divisible into three subunits: a basal sandstone approximately 200 feet thick; a thin sequence of shale exposed only at Marysville; and an upper sandstone somewhat less than 200 feet thick. The basal 200 feet of the lower sandstone contains local beds of conglomerate and shale. The upper sandstone subunit exhibits cross-bedding as well as scour and fill structures, has local conglomerates, and is topped by a conglomeratic bed that is particularly well developed at Girty's Notch.

Table 2.—*Assemblage zones of the Mahantango Formation of Perry and adjacent counties.*

Upper shale member
- *Sulcoretepora* cf. *S. incisurata* Zone
  - *Pustulatia pustulosa* Zonule
  - *Craniops hamiltoniae* Zonule
- Upper *Tropidoleptus carinatus* Zone
- *Pustulatia pustulosa* Zone
- Lower *Tropidoleptus carinatus* Zone
  - *Rhipidomella leucosia* Zonule
  - *"Spirifer" tullius* Zonule
- *Devonochonetes scitulus* Zone
- *Mucrospirifer mucronatus* Zone

Montebello Sandstone Member
- *Devonochonetes coronatus* Zone
- *Mediospirifer*-coralline Zone
- *Subrensselandia claypolii* Zone
- *Paraspirifer acuminatus* Zone

This conglomerate is present at Falling Springs and at Amity Hall where it contains abundant specimens of spirifers. At Marysville and Millerstown, the same horizon is represented by several sandy biostromes that abound in corals and brachiopods.

The middle shale unit of the Montebello Member contains numerous beds of thin-bedded sandstone and siltstone that increase in proportion toward the top of the unit, grading into the overlying unit of sandstone. This unit is recognizable throughout Perry County, the alternating beds of shale and thin-bedded sandstone being quite distinctive.

The upper unit of sandstone of the Montebello Member is locally conglomeratic and shaly. At several sections, the upper 25 feet of this sandstone is a grayish-red or purple siltstone capped by 4 to 10 feet of medium-greenish-gray sandstone. The thickness and character of the upper sandstone changes considerably throughout Perry and adjacent counties. In all sections where the top of this sandstone unit is exposed it is capped by a thin bed of oolitic hematite.

The upper shale member overlies the hematitic bed in all sections except those at Rockville and Marysville. In the section at Rockville, an upper shale, equivalent to the basal portion of the upper shale member in other Perry County sections has been included in the Montebello sandstone. This shale is overlain by another sandstone unit that is chiefly sandstone and siltstone with numerous beds of conglomerate and shale. This sandstone possibly correlates with beds of sandstone and siltstone disposed within the upper shale member at other sections, but such a correlation has not been demonstrated (Plate 1).

The contact between the Montebello Sandstone Member and the overlying shale member is, at most sections, abrupt, being marked by a bed of oolitic hematite at the top of the Montebello. However, at Rockville and Marysville, the Montebello continues above this hematite as a sandstone unit.

In the sections at Rockville and Marysville, an upper shale unit and a sandstone unit, equivalent to the lower portion of the upper shale member in other sections in Perry County, have been included in the Montebello Member. The fauna of the shale unit is unlike other faunas of the Montebello and bears little resemblance to the fauna of the lower part of the upper shale member. The upper unit of sandstone is chiefly sandstone and siltstone with numerous beds of conglomerate and shale; this unit may correlate with beds of sandstone and siltstone disposed within the upper shale member at other sections, but such a correlation has not been demonstrated (Plate 1).

Concentrations of fossils, dominated by species of brachiopods, are abundantly scattered through the Montebello Member. Certain assemblages (see table 2) are useful in establishing stratigraphic position within this member.

The lowermost zone, or *Paraspirifer acuminatus* Assemblage Zone, is represented by one horizon at Marysville where that species is especially abundant, by two horizons at Millerstown, and perhaps by a single horizon in the Dromgold and Falling Springs sections where *Rhipidomella penelope* is common.

Still within the lower unit of sandstone of the Montebello Member in the Dromgold and Falling Springs sections, the *Subrensselandia claypolii* Assemblage Zone is characterized by accumulations of shells of that species. This is the only definite occurrence of *S. claypolii* in the present study area.

The upper few feet of this lower unit of sandstone in the Montebello Member, in some sections, is topped by a conglomeratic sequence, and in other sections by fossils of the *Mediospirifer*-coralline Assemblage Zone. At Amity Hall and Girty's Notch, both the conglomerate and the *Mediospirifer*-coralline Zone are present. This zone is characterized by indeterminate species of horn corals, *Favosites* sp., *Pleurodictyum stylopora*, *Protolepetostrophia perplana*, *Devonochonetes coronatus*, *Retichonetes marylandicus*, *Mediospirifer* sp., and *Spinocyrtia granulosa* and its subspecies. Occurrence of a large and diversified fauna 595 feet above the base of the section at Rockville may be representative of this upper fossiliferous level or may be slightly higher. Several genera that are present in the fauna at 595 feet at Rockville, such as *Sulcoretepora*, *Delthyris*, *Actinopteria*, and *Palaeoneilo*, have not been seen in the lower unit of sandstone at other sections.

In most of the sections in Perry County, the lower unit of sandstone with its *Mediospirifer*-coralline Zone at the top is overlain by a sequence of alternating beds of siltstone and shale with pocket-like and blanket-like accumulations of fossils of the *Devonochonetes coronatus* Zone. This assemblage zone includes specimens of *Devonochonetes coronatus*, *D. syrtalis*, *Camarotoechia congregata*, *Tropidoleptus carinatus*, *Mediospirifer? bellitropis*, and *Trimerus (Dipleura) dekayi*.

Except in the Mahantango Creek and Millerstown sections, the upper unit of sandstone is not appreciably fossiliferous. At Millerstown, the lower half of this upper sandstone contains abundant *Devonochonetes coronatus*, *Mucrospirifer mucronatus*, and *Tentaculites attenuatus*, all more or less psammophilic species; the upper half of the unit of sandstone contains abundant specimens of *"Spirifer" tullius*. At Mahantango Creek, only one fossiliferous horizon has been observed in this part of the section and the assemblage is unusual, being dominated by gastropods, chiefly *Ianthinopsis?* sp.

At Rockville, the shale unit above the oolitic hematite, but here included in the Montebello Member, has a rather atypical fauna containing *Pholidostrophia pennsylvanica*, *Athyris spiriferoides*, and *Cornellites*

flabella, species not found in the Montebello elsewhere. This fauna is more nearly like that of the *Sulcoretepora* Zone of the upper part of the upper shale member.

The uppermost unit of sandstone included in the Montebello Member at Rockville and Marysville has a fauna that is dominated by *Tropidoleptus carinatus, Camarotoechia congregata,* and *Mediospirifer audaculus.*

Upper Shale Member

Although in most sections throughout Perry County only portions of the upper shale member can be observed, enough information is available to suggest that the member has a rather uniform thickness (Plate 1). The most reliable measurements of thickness were obtained at Amity Hall and New Bloomfield, where both the top and the base of the upper member are exposed. At both of these sections, the upper shale member is about 280 feet thick.

In Perry County, the upper shale member contrasts strikingly with the underlying Montebello Sandstone Member. At most sections a distinctive bed of oolitic hematite marks the top of the Montebello. At New Bloomfield, the upper shale member is predominantly a medium-olive-gray claystone, with two thin sequences of greenish-gray and olive-gray siltstone. Toward the northeast, at Amity Hall, Girty's Notch, and Mahantango Creek, the upper member is composed chiefly of shale, with minor beds of sandstone and siltstone. The sandstone, siltstone, claystone, and shale portions of this member are not readily correlated between sections in this area. Generally, the subunits of the upper member grade vertically and laterally into one another.

The Mahantango Formation grades into the overlying Tully limestone, and at Girty's Notch and New Bloomfield the concretions of limestone in the upper 30 feet of the upper shale member probably presage the Tully. However, these concretions at Girty's Notch carry Hamilton species such as *Pholidostrophia pennsylvanica, Douvillina inaequistriata* var. *immatura,* and *Tropidoleptus carinatus.*

The upper shale member contains an exceptionally large and diversified fauna that includes nearly all of the species found in the Mahantango Formation. Collectively, this fauna is characterized by *Sulcoretepora* cf. *S. incisurata, Fenestella* cf. *F. emaciata, Devonochonetes scitulus, Pustulatia pustulosa, Mucrospirifer mucronatus, "Spirifer" tullius,* and *Tropidoleptus carinatus.*

The species found in the upper shale member vary markedly in actual and comparative abundance in successive beds, in a manner that is widely persistent within and beyond the boundaries of Perry County. On the basis of abundance, but, generally, not because of any restriction of total

ranges, it has been possible to trace and make stratigraphic use of the assemblage zones listed in table 2, in Perry County.

Characteristics and occurrences of the zones found in the upper shale member in Perry and adjacent counties can be summarized as follows:

1. *Mucrospirifer mucronatus* Assemblage Zone.—The *M. mucronatus* Zone is the lowermost zone of the upper shale member in Perry County. It ranges in thickness from less than 10 to as much as 15 feet and, in addition to *M. mucronatus,* contains abundant specimens of *Devonochonetes scitulus, Paracyclas lirata, Bembexia laevis,* and other forms including numerous species of pelecypods. One of the most widespread of the faunal zones, the *M. mucronatus* Zone immediately overlies the oolitic hematite at Amity Hall, Girty's Notch, and in an exposure near Roseburg. At New Bloomfield, a collection of specimens from 47 feet above the base of the described section is, in many respects, similar to the fauna of the *M. mucronatus* Zone, and this fauna is tentatively referred to the *M. mucronatus* Zone.

2. *Devonochonetes scitulus* Assemblage Zone.—The *D. scitulus* Zone is a rather indefinite zone both in thickness and paleontologic character. The occurrence of *D. scitulus* represents a continuation of that species from the *M. mucronatus* Zone. Separation of this zone from that of *M. mucronatus* is based on the abundance of *D. scitulus* and scarcity of other species. The zone is present in the three sections in which the lower part of the upper shale member is exposed.

3. *Lower Tropidoleptus carinatus* Assemblage Zone.—The lower *T. carinatus* Zone ranges in thickness from 20 feet at Dromgold to 36 feet at Mahantango Creek. It is not present at Amity Hall. This zone may be further subdivided into the following two zonules:
   a. *"Spirifer" tullius* Zonule.—The lowermost zonule of the lower *Tropidoleptus carinatus* Zone is characterized by an abundance of *"Spirifer" tullius,* and ranges in thickness from less than 1 foot at New Bloomfield and Dromgold to 2 feet at Mahantango Creek. The fauna at Mahantango Creek is unusually diversified for the *"Spirifer" tullius* Zonule, containing several spicies of *"Chonetes,"* pelecypods, and gastropods, as well as *Mucrospirifer mucronatus* and *Trimerus (Dipleura) dekayi,* all in abundance.
   b. *Rhipidomella leucosia* Zonule.—The *Rhipidomella leucosia* Zonule is represented by a thickness of 2 feet at Mahantango Creek and New Bloomfield, and by 17 feet at Dromgold. It overlies the *"Spirifer" tullius* Zonule. The following species are common in this zonule at New Bloomfield and Dromgold: *Sulcoretepora* cf. *S. incisurata, Rhipidomella leucosia, Protoleptostrophia perplana, "Chonetes"* sp., *Productella spinulicosta, Delthyris sculptilis,*

Mediospirifer audaculus?, Mucrospirifer mucronatus, Coruellites flabella, Modiomorpha concentrica, and *Trimerus (Dipleura) dekayi.* The assemblage at Mahantango Creek is somewhat different, consisting of *Devonochonetes scitulus, D. coronatus, Cypricardella bellistriata, C. tenuistriata, Hollinella* cf. *H. sella,* and other indeterminate species of ostracodes.

4. *Pustulatia pustulosa* Assemblage Zone.—The *P. pustulosa* Zone is represented by one stratigraphic level at Amity Hall and at Mahantango Creek. *Pustulatia pustulosa* is common or abundant, and *Tropidoleptus carinatus, "Chonetes"* species, and crinoid columnals also may be present.

5. Upper *Tropidoleptus carinatus* Assemblage Zone.—The upper *T. carinatus* Zone is represented by one stratigraphic level at Dromgold and a sequence about 30 feet thick at New Bloomfield. At New Bloomfield, the following forms are abundant: *Tropidoleptus carinatus, Devonochonetes scitulus, D. coronatus, "Chonetes"* sp., *"Spirifer" tullius,* species of pelecypods and gastropods, and *Trimerus (Dipleura) dekayi.*

6. *Sulcoretepora* cf. *S. incisurata* Assemblage Zone.—The *S.* cf. *S. incisurata* Zone is the most extensive zone in the upper shale member, and ranges in thickness from 17 to 30 feet. Wherever the upper portion of this member is exposed, the *Sulcoretepora* Zone is present and well developed. The fossils are concentrated in swarms in several thin layers within the upper part of the member. Most of the species of the Mahantango Formation are found in this zone, the more common species being: *Fenestella* cf. *F. emaciata, Sulcoretepora* cf. *S. incisurata, Douvillina inaequistriata, D. inaequistriata* var. *immatura, Schuchertella variabilis, Pustulatia pustulosa, Delthyris sculptilis, Tylothyris pauliformis, Elytha fimbriata, Mediospirifer audaculus, "Spirifer" tullius, Ambocoelia umbonata, Actinopteria decussata, Cypricardella indenta, Palaeoneilo constricta, P. muta, Modiomorpha concentrica, Greenops boothi, G. boothi* var. *calliteles, Phacops rana, Ctenoloculina cicatricosa, Hibbardia lacrimosa,* and *Hollinella* species. Within the *Sulcoretepora* Zone, the two following zonules are persistent throughout Perry County, in ascending order:

   a. *Craniops hamiltoniae* Zonule.—The *C. hamiltoniae* Zonule is present in the three sections in which the *Sulcoretepora* Zone is exposed. Its abundant and diversified fauna includes numerous species of ostracodes in addition to *Craniops hamiltoniae.*

   b. *Pustulatia pustulosa* Zonule.—The *P. pustulosa* Zonule is the uppermost zonule in the sections at Girty's Notch and New Bloomfield.

MAHANTANGO FORMATION OF BEDFORD AND FULTON COUNTIES

General Statement Concerning Stratigraphy

Southwestward from Perry County, in Bedford and Fulton Counties, the Mahantango Formation thins to an average thickness of 1,200 to 1,300 feet and becomes increasingly argillaceous so that sandstone forms only about 20 percent of the formation. The tripartite character of the formation, so obvious in Perry County, also is apparent in Bedford and Fulton Counties, although the median unit here primarily is siltstone and shale rather than sandstone.

Determination of the stratigraphic relationships of the units within the Mahantango Formation of Bedford and Fulton Counties is difficult, largely owing to the recurrence of similar lithotypes and their associated faunas. However, three members, in ascending order, the Gander Run Shale Member, the Chaneysville Siltstone Member, and the Frame Shale Member (Willard, 1935c) are readily recognized, and evidence supports the conclusion that the three members grade vertically and laterally into one another. The presumed facies relationships of the members of the Mahantango Formation in Bedford and Fulton Counties are shown in Plate 2.

The faunal zonation of the Mahantango Formation in Bedford and Fulton Counties, as presently understood, is summarized in table 3.

Table 3.—*Assemblage zones of the Mahantango Formation of Bedford and Fulton Counties.*

Frame Shale Member
- *Sulcoretepora* cf. *S. incisurata* Zone
- *Tropidoleptus carinatus* Zone
  - *Mucrospirifer mucronatus-"Spirifer" tullius* Zonule
  - *Protoleptostrophia perplana* Zonule

Chaneysville Siltstone Member
- *Mucrospirifer mucronatus* Zone
  - In Bedford County:
    - *Spinocyrtia granulosa clintoni* fauna
    - *Longispina mucronatus* fauna
  - In Fulton County:
    - *Devonochonetes coronatus* fauna
    - *Protoleptostrophia perplana* fauna
- *Mediospirifer audaculus* Zone

Gander Run Shale Member
- *Leiorhynchus limitare* fauna

The three-fold lithologic succession — shale, sandstone or siltstone, and shale — of the Mahantango Formation in south-central Pennsylvania

provides the basic framework around which the correlation of intraformational units has been erected. Implicit in the stratigraphic relationships shown in Plates 1, 2, and 3 is one of the following: a widespread cycle of marine regression and transgression, presumably in response to changing tectonic activity in the source area; or a gradual elevation and subsequent wearing down of the source area.

Gander Run Shale Member

The term Gander Run Member was introduced by Willard (1935c, p. 1279) as a local term to designate the lower shaly portion of the Mahantango Formation in Bedford County. As originally defined, the Gander Run Member is a "brown weathering, dark-gray, sandy shale with shaly sandstone . . . is rarely well exposed and nearly barren." As described in the present study, the Gander Run Member consists of olive-gray and medium- to dark-gray, silty shale and claystone, as well as medium-gray, argillaceous, and slightly calcareous siltstone. In the section at Bedford, the Gander Run Member is composed of nearly 400 feet of medium- to dark-gray shale that is silty in the upper 300 feet of its exposure. Toward the east, at Websters Mill, and toward the south, at Chaneysville, the Gander Run shale becomes increasingly silty, particularly in its upper portion. Indeed, the Gander Run Member as exposed at Chaneysville is described here as an argillaceous siltstone rather than a shale. At Websters Mill, beds of siltstone increase in proportion toward the top of the exposed Gander Run Member.

The top of the Marcellus black shale in Bedford and Fulton Counties has been found exposed only in the sections at Bedford and at Websters Mill. These two sections, therefore, provide the most reliable estimates of the thickness of the Gander Run Member. The exposed thickness of the Gander Run Shale Member is 393 feet at Bedford and 666 feet at Websters Mill. Willard (1935) assigned a thickness of 850 feet to the Gander Run Member at Chaneysville. The author measured nearly 200 feet of unfossiliferous, very argillaceous siltstone along Sweet Root Creek at Chaneysville, but was unable to locate the Marcellus black shale or the base of the Mahantango Formation.

That the Gander Run Member of Bedford and Fulton Counties is in part equivalent to the Marcellus black shale to the west is suggested by the reappearance of the *Leiorhynchus limitare* fauna, so distinctive of the Marcellus Formation, in the Gander Run shale of the Bedford section. Laminae of black shale, evident in the Gander Run Member of Huntingdon County, have not been observed in the Gander Run Member of Bedford and Fulton Counties.

The contact between the Gander Run shale and the Chaneysville siltstone also is gradational; in some sections, beds of siltstone within the

Gander Run Member increase in proportion toward the base of the Chaneysville Member, and in other sections, the shale becomes increasingly silty toward the base of the Chaneysville Member.

Although the Gander Run Member of Bedford and Fulton Counties, like the lower shale of Perry County, is, in general, relatively unfossiliferous, two fossil assemblages have been described. In the section at Websters Mill, abundant specimens of *Devonochonetes scitulus* were found 545 feet above the base of the Mahantango Formation, in association with numerous shells of *Leiopteria laevis, Orthonota undulata,* and *Bembexia sulcomarginata?*. The recurrent *Leiorhynchus* fauna, in the section at Bedford, is found 78 feet above the base of the Mahantango Formation and contains abundant examples of *Paleschara radiata, Leiorhynchus limitare, Leiopteria laevis, Leptodesma rogersi,* and *Styliolina fissurella,* as well as specimens of *Productella truncata, Camarotoechia prolifica,* and *Bembexia sulcomarginata.*

Chaneysville Siltstone Member

The Chaneysville Siltstone Member in Bedford and Fulton Counties is paleontologically and lithologically one of the most varied of all of the members of the Mahantango Formation in south-central Pennsylvania. Recognition of traceable units within the Chaneysville Member is difficult with available information, but two assemblage zones have been established (table 3).

As originally described by Willard (1935c, p. 1279) at its type section, the Chaneysville Member is predominantly a "hard, olive-gray, brown-weathering, platy to submassive sandstone (that) is fossiliferous." In the present description of the same section, the Chaneysville Siltstone Member includes, in ascending order, 300 feet of argillaceous siltstone, a 33-foot concealed interval, and 9 feet of argillaceous siltstone. The siltstones are micaceous and occur in beds ranging from 1 to 18 inches in thickness. At Chaneysville and Everett, the lower and upper portions of the Chaneysville Member predominantly are siltstone, but at Websters Mill the lower portion is represented by very silty claystone.

Several lines of evidence have been considered in interpreting the stratigraphic relationships of units within the Chaneysville Member, and these may be grouped under three broad headings: stratigraphic equivalence based on sequential positions, stratigraphic equivalence based on similarity of rock types, and stratigraphic equivalence based on similarity of faunas. In the Chaneysville Member, the evaluation of faunal and lithologic evidence for purposes of correlation is complicated by the remarkable similarity of recurrent facies. Few, if any species in the Mahantango Formation, with the possible exception of *Fimbrispirifer venustus,* appear to be restricted to particular horizons.

The Chaneysville Siltstone Member is nearly 350 feet thick in Bedford and Fulton Counties, and may be divided into three units: a lower siltstone, a middle shale, and an upper siltstone (Plate 2). The Chaneysville Siltstone Member, although chronologically equivalent, at least in part, with the Montebello Sandstone Member of Perry County, contrasts strikingly with that member in being thinner and more evenly bedded, and in being composed of siltstones that are almost wholly of the micaceous type.

The earliest major incursion of organisms during deposition of the silts of the Chaneysville Member is represented by the *Mediospirifer audaculus* Assemblage Zone. This fauna is dominated by horn corals; brachiopods, such as *Tropidoleptus carinatus,* species of *"Chonetes,"* and *Delthyris sculptilis;* and the pelecypod species *Cornellites flabella.* At Everett and Websters Mill, *Mucrospirifer mucronatus* is common in the upper part of this zone. The *M. audaculus* Zone is especially well developed at Chaneysville, where it contains one of the largest assemblages observed in the Mahantango Formation at any place in south-central Pennsylvania. Brachiopod species additional to those listed above occur, and there are numerous specimens of bryozoans, auloporoid corals, and *Pleurodictyum styloporum. Fimbrispirifer venustus* is in this zone at Chaneysville, and suggests correlation with the Centerfield Member of the Ludlowville Formation in New York. The upper 90 feet of the *M. audaculus* Zone at Chaneysville contains little more than *Longispina mucronatus.*

In all of the sections studied in Bedford and Fulton Counties the *Mediospirifer audaculus* Zone is succeeded by an unfossiliferous sequence. This barren zone is approximately 40 feet thick at Websters Mill, 50 feet thick at Chaneysville, and 70 feet thick at Everett.

The fauna of the *Mucrospirifer mucronatus* Assemblage Zone represents the second major incursion of organisms that occurred during deposition of the Chaneysville Siltstone Member, and, inasmuch as the faunal composition varies widely across the area of Bedford and Fulton Counties, this zone will be considered separately at the Everett, Websters Mill, and Chaneysville sections (table 3).

At Everett, the *M. mucronatus* Zone is over 50 feet thick and contains floods of *Mucrospirifer mucronatus.* Furthermore, any or all of the following fossils may occur with *M. mucronatus:* species of bryozoans, *Tropidoleptus carinatus, Devonochonetes coronatus, D. scitulus, Retichonetes vicinus, Longispina mucronatus,* and species of pelecypods. Crinoid columnals are abundant, especially in the lower part of this zone.

The fauna of the lower 60 feet of the *M. mucronatus* Zone at Websters Mill contains abundant specimens of *Protoleptostrophia perplana* in addition to *M. mucronatus.* In contrast, the upper portion of the same

zone at Websters Mill carries abundant shells of *Devonochonetes coronatus* and *M. mucronatus,* but lacks specimens of *P. perplana.*

At Chaneysville, the lower fauna in the *M. mucronatus* Zone is dominated by *Longispina mucronatus* and *M. mucronatus,* whereas the upper fauna of the same zone abounds with specimens of *Spinocyrtia granulosa clintoni,* bryozoans, pelecypods, and crinoid columnals. The rather explosive appearance of *Spinocyrtia* at this position preludes its introduction at Websters Mill and Everett, somewhat higher in the Chaneysville Member, and presumably correlates with its appearance in the upper part of the Chaneysville siltstone at Fishertown.

The faunal zonation of the Chaneysville Member presented here is, at best, tentative and subject to revision with the accumulation of further information concerning the distribution of species within the Mahantango Formation.

Frame Shale Member

The upper, fossiliferous shale of the Mahantango Formation in Bedford County has been termed the Frame Member by Willard (1935c, p. 1279). He described it as a "gray to olive, sandy shale which carries thin, local sandstones and an occasional thin limestone lens. Fossils are usually plentiful." The type section for the Frame Member is at Chaneysville, although the name is taken from the Frame School, several miles north of Chaneysville.

In Bedford and Fulton Counties the Frame Member averages about 300 feet thick. This is similar to the average 278-foot thickness of the upper shale member in Perry County.

The Frame Member in Bedford and Fulton Counties is composed of medium gray and olive-gray, silty shale and claystone, and beds and concretions of siltstone that are argillaceous or calcareous. At Websters Mill, the top of a 122-foot sandstone is 20 feet below the top of the Mahantango Formation.

The nature of the contact of the Frame Member with overlying sedimentary rocks is a perplexing problem. In every section in which the Frame Member is exposed, at least a part of the sequence from the lower part of the Frame Member into the Upper Devonian Brallier (?) Formation is missing, either by unconformity or by facies change. At Bedford, the *Sulcoretepora* Zone that is so conspicuous near the top of the Frame Member in other sections is absent but the Tully limestone, Burket black shale, and Harrell shale are well developed. At Elk Lick Creek, the *Sulcoretepora* Zone of the Frame Member is present, but it is overlain by sandstone containing *Tropidoleptus carinatus* and *Mucrospirifer mucronatus* in modest numbers, rather than by limestone or black shale. The *Sulcoretepora* Zone is overlain by shale and siltstone in the section at Websters Mill, but there the overlying unit is unfossiliferous.

In a small exposure at Everett, the upper part of the Frame shale, the Tully, if present, and the lower part of the Burket black shale are concealed, but alternating laminae of siltstone and black shale at the upper contact of the Burket suggest that the Burket, at least, passes toward the southeast into siltstone facies. Such, indeed, also may be the case with the Tully limestone.

At Bedford, the *Sulcoretepora* Zone of the upper part of the Frame Member is absent. If the *Sulcoretepora* Zone elsewhere is equivalent to the Tully limestone at Bedford, the relationship is similar to that existing between the Apulia and West Brook Members of the Tully Formation in New York. The fauna of the *Sulcoretepora* Zone of the Mahantango Formation of south-central Pennsylvania is strikingly similar to that of the West Brook Member of the Tully Formation of New York. Farther toward the east, at Websters Mill, the Tully and Burket Members of the Rush Formation apparently are replaced by unfossiliferous shales, siltstones, and sandstones.

The faunal zonation of the Frame Member, as shown in table 3, is a composite derived from several sections, inasmuch as no single section includes the entire Frame Member.

As in Perry County, the *Sulcoretepora* Zone in Bedford and Fulton Counties is the most fossiliferous zone in the Mahantango Formation. Individuals and species generally are more numerous in this zone than in any other, and the fauna abounds in specimens of bryozoans, brachiopods, pelecypods, and ostracodes. Among the species that are restricted to this zone are *Craniops hamiltoniae, Schuchertella variabilis, Cypricardella bellistriata, Palaeoneilo emarginata, Adelphobolbina medialis,* and *Ponderodictya punctulifera.*

MAHANTANGO FORMATION OF HUNTINGDON AND BLAIR COUNTIES

General Statement Concerning Stratigraphy

The Mahantango Formation of Stone Valley in Huntingdon County is less than 1,000 feet thick and is composed primarily of shale and claystone with approximately 10 percent siltstone. In addition to the smaller grain size as compared to the sediments from Perry, Bedford, and Fulton Counties, the Mahantango Formation of Huntingdon County contains numerous beds and concretions of limestone and calcareous siltstone. The base of the formation has been observed to be gradational in the measured section at Huntingdon. Most exposures in the area are siltstone; therefore, much of the formation presumed to be shale is not fully understood.

The Marcellus Formation is a black, fissile shale, whereas the basal part of the Mahantango Formation is a medium-dark-gray and olive-gray claystone or shale. Although rocks of the Mahantango Formation commonly are olive-gray, this color very likely is the result of weathering. Fresh exposures of the formation are almost invariably medium gray to medium dark gray.

In the section at Newry, Blair County, and lying in sharp contact on the Frame shale, a 3-foot thickness of Tully limestone and calcareous shale has yielded specimens of *Hypothyridina venustula* and *Emmanuella pennsylvanica*. At Huntingdon, however, the upper Mahantango contact is gradational and poorly defined. Here, the black shale of the Burket Member of the Harrell Formation and the medium-gray shale of the Mahantango Formation are separated by a 5-foot sequence of shale that carries a fauna in which *Echinocoelia ambocoeloides, Leiorhynchus mesacostale?,* and *Styliolina fissurella* are common. Such an assemblage is strongly suggestive of a Tully age for this 5-foot shale.

Five members are recognized in the Mahantango Formation of Huntingdon County. In ascending order, the members are the Gander Run Shale Member, the Backbone Ridge Siltstone Member, the Crooked Creek Shale Member, the Donation Siltstone Member, and the Frame Shale Member. These five members correspond with the five-fold subdivision of the Hamilton as proposed by White.

Although nearly all of the observed fossil species range through the Mahantango Formation at Huntingdon, the exposed portions of the formation may be divided, on the basis of assemblages as well as local ranges, into several faunal zones, as shown in table 4. As is generally true for the Mahantango Formation, faunas may recur vertically wherever similar environmental conditions are represented. However, faunas of the same biofacies do not always reappear with sediments of the same lithofacies, nor do recurring sediments of the same lithofacies always contain faunas of the same biofacies.

The following species are more or less restricted stratigraphically, as observed in Huntingdon and Blair Counties:

1. Frame Shale Member—*Mucrospirifer mucronatus, Cypricardinia indenta, Greenops boothi* var. *calliteles, Proetus rowi.*
2. Donation Siltstone Member—*Pholidostrophia pennsylvanica.*
3. Crooked Creek Shale Member—*Leiorhynchus multicostum, Modiomorpha concentrica.*
4. Backbone Ridge Siltstone Member—*Devonochonetes coronatus.*
5. Gander Run Shale Member—*Leiorhynchus limitare, Prothyris lanceolata.*

Table 4.—*Assemblages of the Mahantango Formation at Huntingdon.*

Frame Shale Member
Sulcoretepora cf. *incisurata* Zone
Tropidoleptus carinatus Zone, including *"Spirifer" tullius* and *Mucrospirifer mucronatus*

Donation Siltstone Member
Delthyris sculptilis fauna
Rhipidomella vanuxemi-Spinocyrtia granulosa fauna

Crooked Creek Shale Member
Bembexia sulcomarginata fauna
Leiorhynchus multicostum fauna
Spinocyrtia granulosa clintoni fauna
Mediospirifer audaculus Zone
Tropidoleptus carinatus fauna

Backbone Ridge Siltstone Member
Mediospirifer audaculus Zone
Protoleptostrophia perplana fauna
Longispina mucronatus fauna

Gander Run Shale Member
Leiorhynchus limitare fauna

At Huntingdon and at Martins Gap, *Rhipidomella vanuxemi, Schuchertella variabilis, Douvillina inaequistriata, Delthyris sculptilis,* and *Elytha fimbriata* make their first appearance in the Donation Member.

Gander Run Shale Member

In the section at Huntingdon, the Gander Run Member consists of olive-gray weathering claystone and shale with a 1- to 4-foot bed of calcareous siltstone in the lower 50 feet and several thinner beds of siltstone near the top of the member. Recognition of the Gander Run Member in Huntingdon County is based on its paleontologic and lithologic aspect. A recurrent Marcellus fauna dominated by *Paleschara radiata, Leiorhynchus limitare,* and *Ambocoelia umbonata* is diagnostic for the Gander Run Member. The gray claystone and shale of the Gander Run Member contrast with the underlying black shale of the Marcellus Formation, and with the overlying beds of siltstone of the Backbone Ridge Member.

In the Huntingdon section, the Gander Run Shale Member is 192 feet thick.

In Stone Valley, the presence of a few, very thin beds of black shale within the Gander Run Member suggests that this member passes laterally into black shales of the Marcellus Formation. As an operational definition, the boundary has been drawn at the lowermost appearance of gray shale.

The upper contact of the Gander Run Member with the Backbone Ridge Siltstone Member is also gradational and the selection of a boundary is somewhat arbitrary. The level at which the sequence becomes predominantly siltstone has been chosen as the boundary between these two members. Such a contact is difficult to recognize in the field, especially in poor exposures, so the uppermost occurrence of the *Leiorhynchus limitare* fauna has been used to supplement the separation. However, the contrast between the low topography on the Gander Run Member and the ridge on the Backbone Ridge Member is a useful mapping criterion.

The *Leiorhynchus limitare* fauna is a carry-over from the underlying Marcellus Formation and is confined at and near Huntingdon to the upper 40 feet of the Gander Run Member, where it contains abundant *L. limitare, Paleschara radiata, Camarotoechia prolifica, Leiopteria laevis,* and less abundant *Longispina mucronatus* and *Styliolina fissurella.* North of the section at Huntingdon, in the Martins Gap section, the Gander Run Member contains in addition to the above-named species numerous species of pelecypods, including *Prothyris lanceolata, Conocardium normale?,* and *Grammysia bisulcata?.* This assemblage of pelecypods has not been observed at any other section, although a *Leiorhynchus limitare* fauna is present in the Gander Run Member of Bedford County.

Backbone Ridge Siltstone Member

The Backbone Ridge Siltstone Member is named here for a medium- to dark-grayish-red siltstone of micaceous-calcareous composition that holds up Backbone Ridge in Huntingdon County. It is well exposed in its type section along U. S. Route 22 opposite Huntingdon where it is 45 feet thick. At Martins Gap, northeast of Huntingdon, the Backbone Ridge Member is about 60 feet thick. The character of the member there, however, has been modified by intense weathering, so determination of boundaries is particularly difficult.

Contact of the Backbone Ridge Siltstone Member with the underlying Gander Run Member and with the overlying Crooked Creek Member is gradational. The upper contact has been placed at the top of a relatively well-defined 1-foot bed of argillaceous siltstone that is somewhat more competent than the overlying rocks and, consequently, exhibits better developed jointing than the overlying rocks.

The basal portion of this member is a very argillaceous siltstone or silty claystone and contains numerous thin beds of calcareous siltstone that are more compact and better cemented than the surrounding beds, and therefore, stand out in relief. Backbone Ridge is a discontinuous ridge along the western limb of the Broadtop synclinorium. This ridge and the ridge supported by the Donation Siltstone Member are the most

conspicuous topographic features of Stone Valley between Warrior Ridge and Standing Stone Ridge.

At Huntingdon, the Backbone Ridge Member contains great numbers of *Protoleptostrophia perplana, Mediospirifer audaculus, Longispina mucronatus, Devonochonetes scitulus, Camarotoechia* sp., but also includes *Devonochonetes coronatus, Actinopteria decussata, Leiopteria laevis,* and *Nuculites oblongatus.* Although *Leiorhynchus limitare* is not found above the Gander Run Shale Member, one of its associated species, *Paleschara radiata,* appears in the Backbone Ridge Member at Martins Gap.

Crooked Creek Shale Member

The Crooked Creek Shale Member is named here for the sequence of claystone and shale that underlies the valley of Crooked Creek, a small tributary of the Juniata River. In its type section along Route 22, opposite Huntingdon, 124 feet of the Crooked Creek Member are exposed. However, a 250-foot concealed interval probably belongs to the Crooked Creek Member, giving it a total thickness of nearly 400 feet. At Martins Gap, 113 feet of this member have been described. The contact with the overlying Donation Siltstone Member (?) is concealed.

The Crooked Creek shale is composed of medium-gray claystone and shale that contain numerous thin beds of calcareous siltstone in the lower 100 feet. Concretions and lenticular bodies of siltstone from 1 inch to 20 feet in diameter are common in the upper two-thirds of the exposed member.

In the section at Huntingdon, the fauna of the Crooked Creek Member contains elements of the Backbone Ridge fauna, such as *Devonochonetes scitulus, Longispina mucronatus, Camarotoechia prolifica, Mediospirifer audaculus,* and *Bembexia sulcomarginata.* In addition, *Tropidoleptus carinatus, Spinocyrtia granulosa clintoni,* and *Modiomorpha concentrica* are common in the lower beds of the Crooked Creek shale. One horizon, 90 feet above the base of this member, contains a fauna unlike any other observed in the middle part of the Mahantango Formation. Abundant specimens of *Leiorhynchus multicostum* are associated with numerous specimens of *Devonochonetes scitulus, Camarotoechia prolifica, Ambocoelia umbonata,* and *Nuculites oblongatus.* This fauna is reminiscent of the *Leiorhynchus* fauna of the Marcellus Formation and the Gander Run Member, but *Leiorhynchus limitare* has been replaced by *Leiorhynchus multicostum.*

Donation Siltstone Member

The type section for the Donation Siltstone Member is along U. S. Route 22 opposite Huntingdon; the name, however, is taken from a

village several miles northeast of Huntingdon in Stone Valley where the Donation Member supports a conspicuous ridge. At the type section, the Donation Member is at least 76 feet thick; contacts of the Donation Member with the underlying Crooked Creek Member and with the overlying Frame Member are concealed. In the Martins Gap section, 135 feet are exposed.

The Donation Member consists of medium-gray argillaceous siltstone that is of micaceous composition (table 1), and silty claystone. The lower and upper parts of the Donation Member as described are shalier than the middle portion. Lenticular beds of calcareous siltstone are present in the lower part of this member.

Rhipidomella vanuxemi dominates the fauna of the Donation Member at levels between 642 and 658 feet above the base of the Mahantango Formation at Huntingdon. The fauna also contains numerous specimens of *Pleurodictyum styloporum*, *Protoleptostrophia perplana*, *Schuchertella variabilis*, *Douvillina inaequistriata*, *Spinocyrtia granulosa*, and crinoid columnals. Between 661 and 672 feet, there are abundant specimens of an auloporoid species, *Taeniopora exigua*, *Delthyris sculptilis*, and crinoid columnals, as well as specimens of *Fenestella*, *Devonochonetes scitulus*, *Schuchertella variabilis*, and others.

At Martins Gap, 551 and 562 feet above the base of the described section, two exceptionally fossiliferous horizons contain faunas that are nearly identical with the Donation faunas at Huntingdon. In addition to the above-named species, the fauna at Martins Gap also contains specimens of *Dechenella macrocephalus* and *Hibbardia lacrimosa*.

Frame Shale Member

The Frame Shale Member is partially exposed at the Huntingdon section in a roadcut-quarry at the junction of U. S. Route 22 with a road that leads northeast across the Juniata River into Huntingdon and southwest along the flank of Piney Ridge. The Frame Member is also partially exposed along this latter road toward the southwest about 1 mile from the intersection with Route 22.

If the beds of the concealed interval between exposures of the Donation Member and the Frame Member at Huntingdon belong to the Frame Shale Member, the thickness of the Frame is nearly 300 feet rather than 185 feet, as described.

Where seen along the Piney Ridge road, the lower 100 feet of the exposed part of the Frame Member consists largely of claystone with a considerable proportion of siltstone. In the overlying beds, nearly 20 feet of siltstone and fine-grained sandstone are exposed at the base of the roadcut-quarry on Route 22. These, in turn, are overlain by medium-

gray claystone that contains *Mucrospirifer mucronatus* and *Tropidoleptus carinatus* in the basal portion that is termed the *Tropidoleptus carinatus* Zone, and becomes increasingly fossiliferous toward the top. Concretionary and lenticular bodies of silty limestone common in the upper half of the claystone contain abundant specimens of *Sulcoretepora* sp., *Devonochonetes scitulus, "Spirifer" tullius,* and crinoid columnals, as well as numerous other species. The fossiliferous concretions and the exceedingly large fauna of the Frame claystone are typical for this member throughout Huntingdon and Blair Counties.

In the upper part of the Frame shale, in the exposure at Huntingdon, the *Sulcoretepora* Zone is succeeded by 6 feet of barren, silty shale. This, in turn, is overlain by 5 feet of shale that is lithologically indistinct from the shale below, and contains small concretions of limestone, as well as a Tully-like fauna including *Emmanuella pennsylvanica?, Leiorhynchus mesacostale?, Echinocoelia ambocoeloides?,* and *Styliolina fissurella.* This 5-foot sequence of shale is overlain by black shales of the Burket Member of the Harrell Formation.

SUMMARY AND CORRELATION OF THE MAHANTANGO FORMATION IN SOUTH-CENTRAL PENNSYLVANIA

Throughout south-central Pennsylvania, the Mahantango Formation maintains a three-fold character, with lower and upper mud rocks sandwiching middle siltstones and sandstones. In Perry and adjacent counties, the formation consists of about 1,600 feet of sedimentary rocks, about 60 percent of which is sandstone. Most of the sandstone is concentrated in the middle, Montebello Sandstone Member. In Bedford and Fulton Counties, the Mahantango Formation is about 1,300 feet thick.

In addition to the thinning of the Mahantango Formation from Perry County to Bedford County, the grain size of the sediments also decreases; sandstone dominates the Montebello Member in Perry County, and siltstone dominates the Chaneysville Member in Bedford and Fulton Counties.

From Perry County to Huntingdon County, the Mahantango Formation decreases in thickness and in the grain size of the sediments, and increases in the content of calcareous beds and organisms. Concomitantly the black shales of the Marcellus Formation are considerably thicker in Huntingdon County than in Perry County, where they actually may be absent in some places. From Bedford County to Huntingdon County, the Mahantango Formation maintains about the same thickness and content of organisms, undergoes a slight decrease in the grain size of the sediments, and an increase in the number of calcareous beds. The tripartite character of the formation in Perry and Bedford Counties, perhaps

representing a major regression-transgression cycle, also is evident in Huntingdon County.

CORRELATION OF THE MAHANTANGO FORMATION OF SOUTH-CENTRAL PENNSYLVANIA

The stratigraphic relationships of the members of the Mahantango Formation, as well as the relationships of the Mahantango Formation with the underlying and overlying formations, as presently understood, are shown in Plate 3. The faunal zones and their interrelationships, as established in the present study, are summarized in figure 5.

Correlation of stratigraphic units within the Mahantango Formation of south-central Pennsylvania involves surface traceability as well as consideration of two broad aspects of the formation, namely, (1) the more or less three-fold lithologic character of the Mahantango Formation and its tectonic implications, and (2) the composition and distribution of faunas.

In Stone Valley, Huntingdon County, and southwestward into Bedford County, the Backbone Ridge Siltstone Member is expressed as a topographic high and is, therefore, easily traced on the surface. Low-lying areas bounding the ridge are underlain by shales of the Gander Run and Crooked Creek Members. Although the Donation Member also supports a ridge, it is less traceable than the Backbone Ridge Member. Toward Everett, the Backbone Ridge Member passes into the lower portion of the Chaneysville Siltstone Member. Members of the Mahantango Formation in Perry County have not been traced into Fulton or Huntingdon Counties, but sections in between indicate that the formation is divisible into 3 members in south-central Pennsylvania.

This tripartite character of the Mahantango Formation in each of the three areas of study serves as a basic framework around which the correlation of intraformational units is constructed. The lower shale, Montebello sandstone, and upper shale sequence in Perry and adjacent counties is replaced toward the southwest by the Gander Run shale, Chaneysville siltstone, and Frame shale sequence in Bedford and Fulton Counties. Toward the north, in Huntingdon County, the lower, Gander Run, shale and the upper, Frame, shale are present but the Chaneysville Siltstone and Montebello Sandstone Members of Bedford and Perry Counties respectively, are represented by the Backbone Ridge siltstone, Crooked Creek shale, and Donation siltstone. The validity of this correlation rests, at least in part, on the validity of the assumption that, within the geographic limits of the present study area, source and basin tectonism are reflected more or less synchronously in the sediments throughout the basin. Relative coarsening of the sediments at one place, in response to

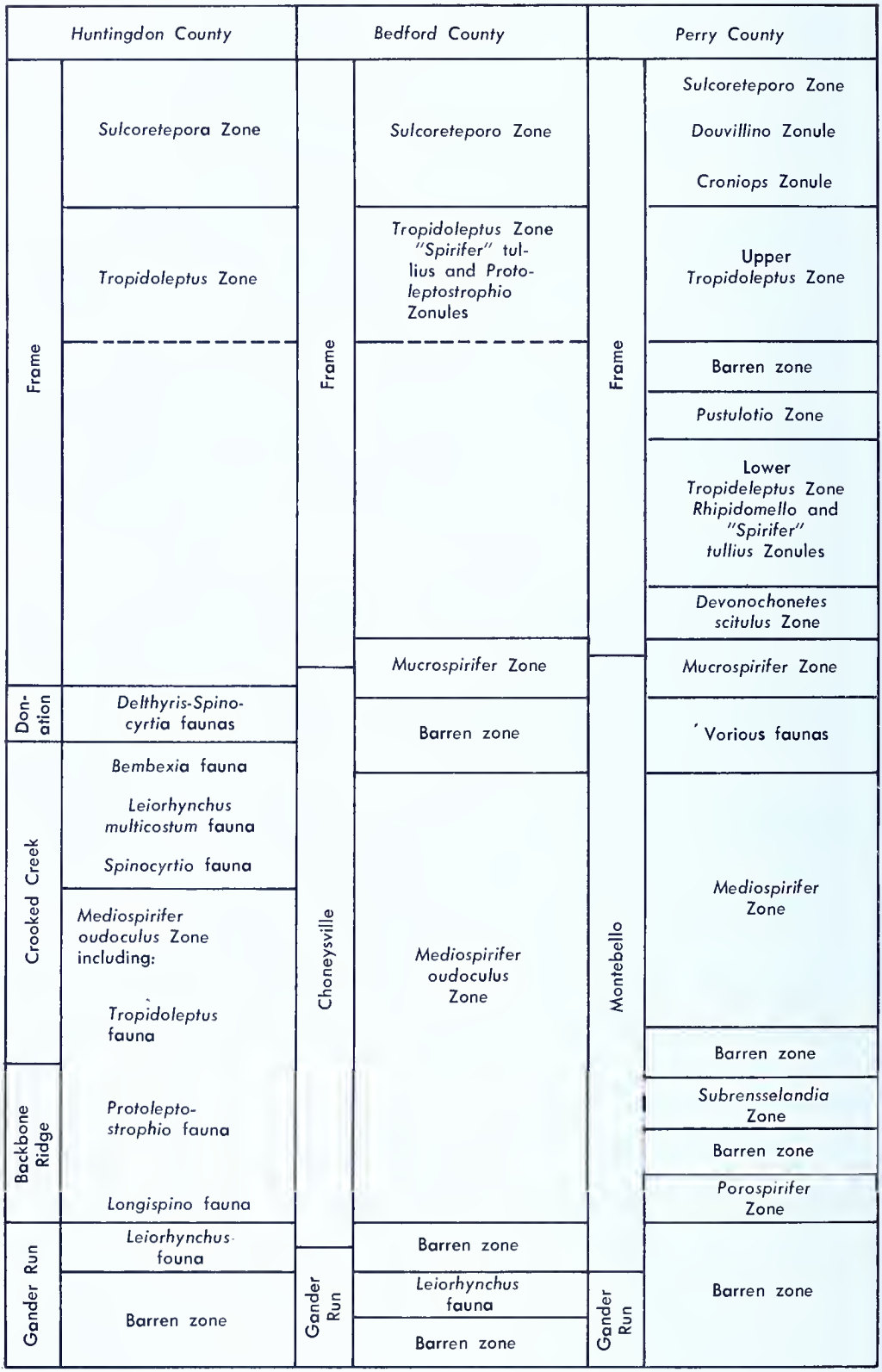


Figure 5. Tentative correlation of the faunal zones of the Mahantango Formotion as described in the three oreos of study in south-central Pennsylvanio.

shallowing of the water, elevation of the source area, or regression of the shoreline, corresponds to relative coarsening of the sediments elsewhere.

Faunal zones of the Mahantango Formation have provided additional means for correlating intraformational units of the Mahantango in south-central Pennsylvania (fig. 5). Some faunal zones are, stratigraphically, more useful than others, by virtue of their lateral persistence, vertical restriction, and relative predictability. Thus, for example, the *Sulcoretepora* Zone of the Frame and upper shale members is found at nearly every section at the top of the Mahantango Formation and, therefore, is considered to be persistent and continuous throughout south-central Pennsylvania. Some species, such as *Devonochonetes coronatus,* are too long-ranging to be stratigraphically useful by themselves; others, such as *Ianthinopsis?* sp. are too restricted geographically to be useful. The following faunal elements appear to be particularly valuable for correlation, and will be considered separately: *Leiorhynchus limitare* fauna; *Mediospirifer*-coralline fauna of the Montebello, Chaneysville, and Backbone Ridge Members; *Mediospirifer* species; *Mucrospirifer mucronatus* and *Tropidoleptus carinatus; Leiorhynchus multicostum* fauna; *"Spirifer" tullius;* and the *Sulcoretepora* Zone.

The *Leiorhynchus limitare* fauna is distinctive for the Gander Run shale at Huntingdon, Martins Gap, and Bedford. At these localities, it includes *Leiorhynchus limitare, Ambocoelia umbonata, Leiopteria laevis, Paleschara radiata,* and modest numbers of other species.

The composition of the *Mediospirifer*-coralline assemblage varies somewhat from the Montebello to the Chaneysville, Backbone Ridge, and Crooked Creek Members. In the Montebello sandstone at Marysville, the *Mediospirifer*-coralline zone contains abundant specimens of *Mediospirifer belliplicata,* as well as numerous specimens of *Retichonetes marylandicus*—a species which is abundant in the *Mediospirifer*-coralline Zone at Everett, horn corals, *Pleurodictyum styloporum, Protoleptostrophia perplana, Devonochonetes coronatus,* and other species. The *Mediospirifer*-coralline Zone includes the biostromes of the Montebello sandstone at Marysville, Amity Hall, and Millerstown, in Perry County. In the Chaneysville siltstone, at Chaneysville, this fauna contains the same species as at Huntingdon, plus abundant specimens of horn corals, *Rhipidomella vanuxemi, Tropidoleptus carinatus, Mucrospirifer mucronatus,* species of *"Chonetes,"* and a host of other species. In the Backbone Ridge siltstone and Crooked Creek shale in Huntingdon County, this fauna includes *Mediospirifer audaculus, Devonochonetes coronatus, Longispina mucronatus, Protoleptostrophia perplana, Pleu.odictyum styloporum,* and a few other species.

All of the species of *Mediospirifer* present in the Mahantango Formation in south-central Pennsylvania, except *Mediospirifer audaculus,* are

restricted to the lower part of the Montebello, Chaneysville, and Backbone Ridge Members. *Mediospirifer audaculus* also is restricted, generally, to the same part of the section as the other species of *Mediospirifer,* but it reappears in the *Sulcoretepora* Zone of the Frame Member. Although in south-central Pennsylvania other species of *Mediospirifer* are restricted to the sandstone facies, *M. audaculus* is found in shale as well as in sandstone. Inasmuch as *M. audaculus* trespasses lithofacies boundaries, its lowermost occurrences in different sections may be nearly contemporaneous.

In the upper part of the Montebello Member of Perry County and adjacent counties, a characteristic sequence of rock units and fossil assemblages is persistent over a broad area. The hematite marking the top of the Montebello Sandstone Member is underlain by grayish-red siltstone, greenish-gray sandstone, and interbedded siltstone and shale. Abundant specimens of *Tropidoleptus carinatus, Camarotoechia* species, *Devonochonetes* species, and *Trimerus (Dipleura) dekayi* within this sequence beneath the hematite represent the *Devonochonetes coronatus* Zone. Generally, this zone is best developed within 10 feet of the underlying conglomerate or coarse-grained sandstone, but at Marysville the *D. coronatus* Zone is about 25 feet above the coarse-grained sandstone. The latter, with specimens of *Mediospirifer,* horn corals, and *Spinocyrtia,* represents the *Mediospirifer*-coralline Zone of Perry County. This sequence in the upper part of the Montebello Member, combined with the composition and persistence of the *Mucrospirifer mucronatus* Assemblage Zone in the lower part of the overlying shale member permit rather precise pinpointing of stratigraphic position in that part of the Mahantango Formation.

Mucrospirifer mucronatus and *Tropidoleptus carinatus* range more or less throughout the Chaneysville and Frame Members of Bedford and Fulton Counties. However, in Huntington and Perry Counties, *M. mucronatus* does not appear below the Frame Member, with the single exception of a horizon in the Montebello sandstone at Millerstown in which this species is abundant. *Tropidoleptus carinatus,* on the other hand, appears in the lower part of the Crooked Creek Member in Huntingdon County, and in the lower part of the Montebello Member in Perry County, and reappears in the Frame Member in both of these areas. It is suggested that Bedford and Fulton Counties may have served as a haven for *Mucrospirifer mucronatus* and *Tropidoleptus carinatus* during deposition of the sediments of the Mahantango Formation, i.e. a location which, speaking solely from the viewpoint of the area of the present study, served as a place from which these two species spread during periods when conditions elsewhere were favorable and to which the two species retreated when conditions elsewhere were less favorable.

Such invasions and retreats of *Mucrospirifer mucronatus* and *Tropidoleptus carinatus* have been regarded as being essentially contemporaneous over their lateral extent.

The sediments containing *Leiorhynchus multicostum* at Huntingdon represent a period of maximum transgression, inasmuch as the genus *Leiorhynchus* commonly is associated with black shales, which generally are regarded as being deeper water sediments. In Perry County, in approximately the same stratigraphic position, a fossiliferous shale and siltstone sequence may represent this same period of maximum transgression. The two faunas, however, are dissimilar.

"Spirifer" tullius appears in the upper part of the Mahantango Formation in all three areas of the present study; in addition, it occurs in the Montebello sandstone at Millerstown, and in the Chaneysville siltstone at Websters Mill. Inasmuch as this species apparently is not confined to any particular lithotype within the present area of study, its appearance in the Frame Member has been regarded as being more or less contemporaneous throughout the area of south-central Pennsylvania.

The ubiquitous *Sulcoretepora* Zone, at all sections occupying the same stratigraphic position at the top of the Mahantango Formation, is believed to be more or less time equivalent throughout its extent in south-central Pennsylvania, if only by virtue of its persistence.

TULLY LIMESTONE MEMBER OF THE HARRELL FORMATION AND ITS RELATIONSHIPS WITH THE MAHANTANGO FORMATION OF SOUTH-CENTRAL PENNSYLVANIA

At Huntingdon, a 5-foot shale between the Frame Member and the Burket shale contains specimens of *Leiorhynchus mesacostale?, Emmanuella pennsylvanica,* and *Echinocoelia ambocoeloides?,* and is presumed to represent the Tully limestone. At Websters Mill, in Fulton County, and at Elk Lick Creek, in southern Bedford County, however, no faunal evidence has been found to relate any of the shales and sandstones lying above the Frame shale in those sections with the Tully limestone elsewhere.

If the correlations described here are correct, the "Tully" increases in thickness from 5 feet at Huntingdon to about 20 feet in Bedford and Fulton Counties.

Several similarities between the Tully of Pennsylvania and that of New York may be noted. Thickness and facies change relatively rapidly, and the unit becomes increasingly sandy toward the southeast. Faunas are somewhat restricted, both vertically and laterally. In Pennsylvania, as in New York, some characteristic Hamilton species, such as *Medio-*

spirifer audaculus, Spinocyrtia granulosa, Pustulatia pustulosa, and *Trimerus dekayi* disappear, and a few species, such as *Hypothyridina venustula, Leiorhynchus mesacostale, Emmanuella pennsylvanica,* and *Echinocoelia ambocoeloides* appear for the first time in the Tully. By and large, however, most species persist from the Hamilton into the Tully, and the faunas look alike. The fauna of the *Sulcoretepora* Zone of the Frame Member of the Mahantango Formation in Pennsylvania resembles that of the West Brook Member of the Tully Formation in New York, in containing common species of corals, bryozoans, brachiopods, mollusks, and arthropods, in abundance. However, the *Sulcoretepora* Zone also contains *Pustulatia pustulosa* and lacks *Hypothyridina venustula,* a fact that suggests that the *Sulcoretepora* Zone is not a West Brook equivalent. Abundant specimens of *Leiorhynchus mesacostale* and *Echinocoelia ambocoeloides* at New Bloomfield are suggestive of the fauna of the Laurens Member of the Tully Formation in east-central New York.

In the present study, the Tully limestone in south-central Pennsylvania is regarded as being represented by several facies analogous to, but not identical with the members of the Tully Formation as recognized in New York. Furthermore, the Tully limestone in Pennsylvania grades vertically and laterally into the overlying and underlying units.

In the section at Newry, the Frame Member of the Mahantango Formation is overlain by three feet of Tully limestone containing a fauna composed chiefly of *Emmanuella pennsylvanica,* but including *Hypothyridina venustula.* Calcareous shale is in the lower portion of the overlying Burket black shale.

In the section at Bedford, the Frame Member is overlain by 17 feet of limestone and calcareous shale containing large numbers of *Atrypa spinosa* and *Ambocoelia umbonata,* suggestive of the Apulia Limestone Member of the Tully Formation in New York.

Toward the south and east, in Pennsylvania, the Tully limestone disappears as a recognizable unit of limestone. At the Amity Hall section, in Perry County, calcareous shale with concretionary bodies of limestone lies between the Mahantango Formation and the Burket black shale. A fauna within this shale and above the limestone concretions contains strictly Hamilton species. At New Bloomfield, a deeply weathered silty claystone occupies this same stratigraphic position. The fauna of this claystone includes such typically Tully species as *Leiorhynchus mesacostale* and *Echinocoelia ambocoeloides,* and is, therefore, presumed to be equivalent with the Tully limestone elsewhere. However, this silty claystone is overlain by claystone containing a typical Hamilton fauna, including *Pustulatia pustulosa.* Because Hamilton faunas sandwich a Tully fauna in parts of Perry County, it is suggested that the Tully and

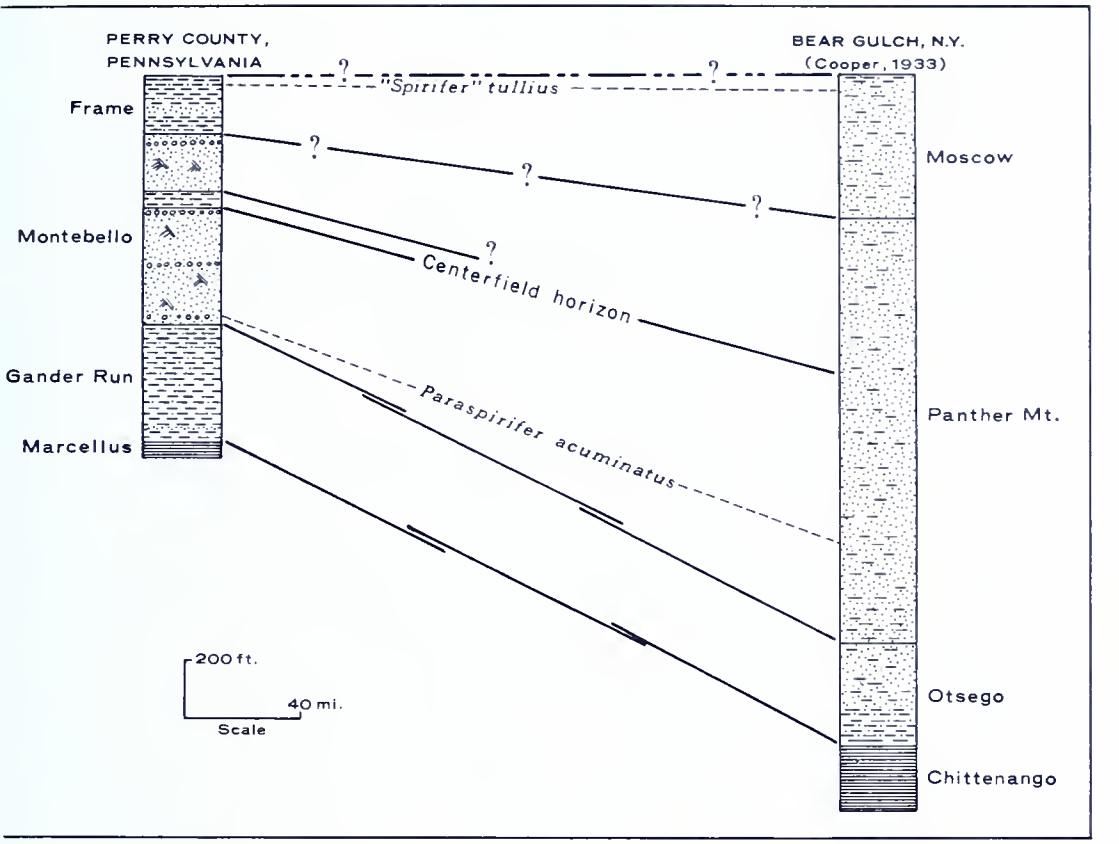


Figure 6. Correlation of the Hamilton Group of south-central Pennsylvania with that of eastern New York.

the upper part of the Mahantango Formation are, in part, laterally equivalent.

In New York, Cooper (1930) and Cooper and Williams (1935) interpret the westward thinning of the upper part of the Hamilton, defined by a horizon of *Pustulatia pustulosa*, as evidence of an unconformity between the Hamilton and the Tully. No such trend nor any other evidence for an unconformity is seen in the Mahantango Formation in Pennsylvania. On the contrary, evidence favors the interpretation that the Tully and the upper part of the Mahantango Formation are laterally equivalent facies.

CORRELATION OF THE MAHANTANGO FORMATION OF SOUTH-CENTRAL PENNSYLVANIA WITH FORMATIONS OF THE HAMILTON GROUP OF NEW YORK

In correlating the Mahantango Formation of south-central Pennsylvania with the Hamilton of New York, recourse has been made to several lines of evidence. The suggested correlation, as shown in figure 6, is based on similarity of lithologic sequences and the inferred tectonic

histories of the two areas, and on the occurrence of several species that appear to be vertically restricted. These bases for correlation are summarized in figure 7.

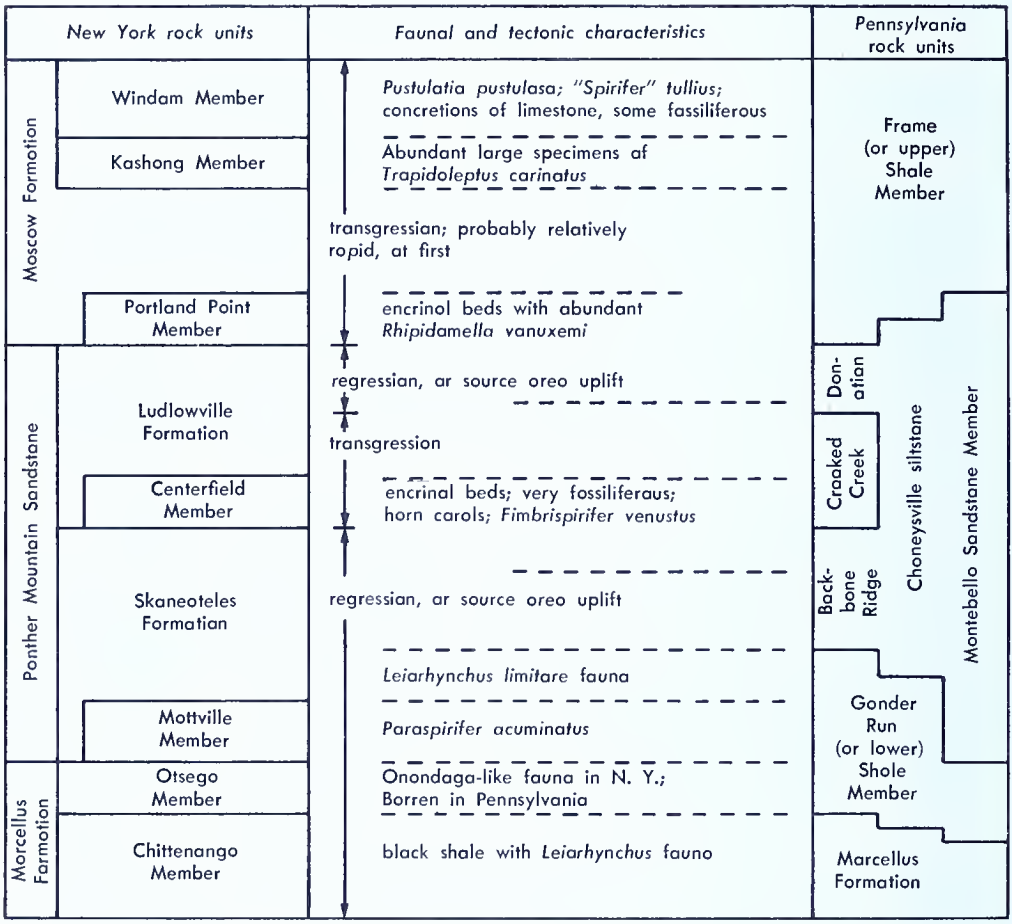


Figure 7. Lines of evidence used in correlating the Hamilton Group of south-central Pennsylvania with that of New York.

In Pennsylvania, Maryland, and New York, the Devonian System is a sequence of rocks beginning with carbonates and ending with redbeds. Although such a sequence represents a gradual withdrawal of the sea from the area, numerous incursions of the sea were superimposed on this general picture. The sediments of the Hamilton Group of New York and Pennsylvania represent such a regression-transgression cycle superimposed on the overall Devonian withdrawal of the sea. It should be noted, however, that elevation of and wearing down of the source area might effect the same sedimentary relationships. In central New York State, the lower shales of the Marcellus and Skaneateles Formations are separated from the upper shales of the Moscow Formation by shales and siltstones of the Skaneateles and Ludlowville Formations, whereas in the eastern part of the State, the Panther Mountain sandstone separates the

lower and upper shales of the Hamilton Group (Cooper, 1930 and 1933). It is suggested here that the introduction of sands of the Panther Mountain sandstone in New York was nearly simultaneous with the introduction of sands of the Montebello Sandstone Member in Pennsylvania; presumably these sands represent increased tectonic activity in the source area.

However, numerous, relatively minor transgression-regression cycles occurred during deposition of sediments of the Hamilton Group, both in New York and in Pennsylvania. In New York, the culminations of four marine advances are represented by the Stafford, Centerfield, Tichenor, and Portland Point Limestone Members. If basin and source area tectonism were synchronous across New York and Pennsylvania, any correlation of the formations of the Hamilton Group of New York with those of Pennsylvania should be compatible with this general geologic history of the region. A period of widespread inundation such as that during which the Centerfield Member was deposited in central and western New York must have some manifestation in Pennsylvania. If these manifestations are preserved, it may be possible to recognize several marine transgressions in Pennsylvania corresponding with those in New York. The problem, therefore, is partly one of determining which sediments representing marine transgressions in Pennsylvania correlate with these four beds of limestone in New York.

The *Leiorhynchus limitare* fauna, so typical of the Skaneateles facies in New York, also is well developed in the Gander Run Member of Huntingdon County, Pennsylvania; however, it is scarcely represented in the Gander Run Member of Bedford County, and it is missing from the lower shale member in Perry County. Presumably, these shales all represent the same lower gray shale unit of the Hamilton Group.

The uppermost occurrence of *Paraspirifer acuminatus*, a large, sharply sulcate brachiopod, is in the lower part of the Montebello Sandstone Member of the Mahantango Formation in Pennsylvania, and in the lower part of the Panther Mountain sandstone of the Hamilton Group in New York. Its disappearance at these levels apparently is not related to any lithofacies changes and is, therefore, regarded as being nearly synchronous across New York and Pennsylvania, although the Panther Mountain sandstone and the Montebello sandstone may be areally discontinuous.

Fimbrispirifer venustus, present in the lower part of the Chaneysville Member at Chaneysville, is diagnostic for the Centerfield Member in New York, although it is also found in the Portland Point Member. In Pennsylvania, *F. venustus* occurs in the *Mediospirifer*-coralline Zone which contains abundant corals as well as large numbers of other invertebrates. Biostromes in other parts of the State correlate with this horizon and suggest the Centerfield Member.

If the Portland Point and Centerfield Members in New York represent periods of maximum transgression, they may be younger or older than their faunally similar counterparts in Pennsylvania, the Backbone Ridge and Donation Siltstone Members, respectively, which, most likely, are regressive deposits.

In the western part of the present study area, the Donation Siltstone Member and the upper part of the equivalent Chaneysville Siltstone Member carry a fauna abounding in crinoid columnals and specimens of *Rhipidomella vanuxemi* and *Spinocyrtia granulosa*. This fauna is especially well developed in the sections at Huntingdon and Fishertown, and is like that of the Portland Point Member in New York.

The persistence of the *Sulcoretepora* Zone and, generally, of the *Pustulatia* Zonule is one of the most important stratigraphic features of the Hamilton Group of south-central Pennsylvania, both for correlating within the State and for correlating between Pennsylvania and New York. The *Sulcoretepora* Zone marks the top of the Mahantango Formation throughout south-central Pennsylvania; however, the *Pustulatia* zonule is absent in places. The middle and upper parts of the Frame Shale Member and the upper shale member of the Mahantango Formation is characterized by *"Spirifer" tullius*. Because *Pustulatia pustulosa* and *"Spirifer" tullius* are characteristic species of the Windom Member of the Moscow Formation in New York, it is proposed that the Windom and the Frame are rock equivalents, and perhaps time-rock equivalents.

HISTORY OF SEDIMENTATION

The sequence of sediments from the Onondaga limestone or Needmore shale, through the Hamilton Group, to the Tully limestone is interpreted as representing a general shallowing followed by a general deepening of the water in the basin of deposition. For the purpose of discussion here it is assumed that this shallowing and deepening was associated with regression and transgression of the shoreline. In all three areas of study the lower member of shale of the Mahantango Formation is succeeded by regressive sandstones or siltstones which are, in turn, overlain by transgressive shales of the upper member. A less extensive transgression in the middle of the Mahantango Formation is represented best in the western portion of the area of study. Two aspects of the sedimentary history bear special consideration—characteristics of regressive and transgressive sequences, and characteristics of the facies represented in the Mahantango Formation.

Oscillations of the sea apparently were more pronounced during regressions of the shoreline than during transgressions, inasmuch as basal contacts of sandstone units with underlying shale generally are grada-

tional, where the upper contact of sandstone units with overlying shales generally are more abrupt. Spieker (in Longwell and others, 1949) found a similar relationship between sandstone and shale in the Cretaceous of Utah, and concluded that rapid transgressions reflect rapid downsinking of the basin.

Oscillatory regressions also may be reflected by the calcareous sediments in the Huntingdon County area. Conditions favorable for limestone generally were not extensive enough for development of continuous beds of limestone. It appears as though concretions rather than beds of limestone may be produced whenever and wherever physical-chemical conditions are discontinuous or oscillatory as they may be during regressions. Thus, the limestone concretions in the Chittenango black shale, as described by Cooper (1930), may be used to infer their regressive nature. Conversely, the continuity of the Stafford limestone separating the Marcellus from the Skaneateles in New York may reflect relatively rapid transgression. Such an interpretation, however, does not imply that all calcareous concretions are the result of regressive depositions; only that under such conditions continuous beds of limestone are less likely to be produced.

Furthermore, faunas of regressive shales contrast with those of transgressive shales. The lower member of shale in the Mahantango Formation, and the Harrell shale both lie beneath units of sandstone and above units of black shale and are believed to be regressive deposits. The barren nature of these two shales is in striking contrast to the extremely fossiliferous, presumably transgressive, Frame Shale Member of the Mahantango Formation. Perhaps regression permits a greater amount of reworking and destruction of shells, or perhaps as Moore has suggested (1954), niches shrink and organisms fail during regressions, whereas during transgressions niches expand and adaptive radiation of organisms results in large and diverse faunas.

The depositional environments of the Mahantango Formation and their characteristics are summarized in table 5; the sedimentary loci given in that table are taken from Cooper's discussion of the paleoecology of the Middle Devonian in eastern and central United States (1957).

During deposition of the Mahantango Formation in south-central Pennsylvania, the source area lay toward the south-southeast. It was composed chiefly of metamorphic rocks, as evidenced by the abundance of metamorphic rock fragments in the Montebello Member. The sea presumably deepened toward northwestern Pennsylvania, where the formation is less than 500 feet thick (Fettke, 1933), and where it is, in part, replaced by black shales of the Marcellus Formation.

At the beginning of Mahantango sedimentation, muds of the lower shale member were being distributed over Perry and adjacent counties,

TABLE 5. *Depositional loci of stratigraphic units of the Mahantango Formation of south-central Pennsylvania.*
(Adapted from Cooper, 1957.)

Depositional loci	*Littoral*	*Epineritic*			*Infraneritic*
		Inner	*Outer*	*Biostromal*	
Lithologic characteristics	well winnowed quartzites; siltstone, sandstone, conglomerate; biostromes; cross-bedding; scour-and-fill	graywackes with much micaceous matrix; siltstone, sandstone; evenly bedded; fossils strewn or concentrated	shale and claystone, in part calcareous; fossils strewn, rarely concentrated	limestone, calcareous shale and claystone; concretions of limestone; abundant fossils; bedding somewhat indistinct	black shale, in part fissile; thin beds
Paleontologic characteristics	brachiopods, especially strophomenids, camarotoechiids, spiriferids; large pterinoids; large trilobites	brachiopods, especially strophomenids, orthids, spiriferids	abundant and diversified faunas, including nearly all invertebrate phyla; largely brachiopods, mollusks, bryozoans, and ostracodes	predominately bryozoans, brachiopods, and trilobites; brachiopods largely rhynchonellids and atrypids	pelagic fauna and dwarfed benthonic fauna; mollusks and brachiopods
Stratigraphic units	Montebello Sandstone Member	Chaneysville, Backbone Ridge, and Donation Siltstone Members	Gander Run?, Crooked Creek, Frame Shale Members and equivalents	Tully Member of Harrell Formation; Frame Shale Member, in part	Marcellus formation; horizon in Crooked Creek Shale Member; Burket Member of Rush Formation

whereas toward the northwest, in Huntingdon County and beyond, these gray muds of the lower shale member grade in part into black muds of the Marcellus Formation that were settling in areas of poor circulation and reducing conditions. Local influxes of sand and silt punctuated deposition of muds of the lower shale member, and conditions unfavorable for life apparently persisted throughout deposition of this member.

Regression resulting from the supply of sediments exceeding the rate of subsidence was triggered by tectonism in the source area which also brought coarser clastics into the basin and marked the beginning of Montebello deposition. In Perry County, the basin of deposition became one of extensive shoals, where shifting currents scoured and filled evanescent channels, and where sands were continually being washed clean of their clay content by wave and current activity. It was an area of plentiful supply of sediment as well as one of continual subsidence, as testified by the great thickness of sediments that accumulated. During Montebello deposition, the sands extended farther and farther into the basin. Mud accumulated locally and, in some instances, over wide areas. Currents were almost continually shifting as evidenced by cross-bedding and the limited areal extent of nearly all units within the Montebello Member. Quartzites of this member are chiefly medium- to coarse-grained sandstones, are rarely evenly bedded, and were deposited by currents of higher intensity than the graywackes which are much finer grained and commonly are evenly bedded. Shales represent deposition in areas of less intensive current activity. Deposition of gravel and coarse sand may have been concentrated near the mouths of rivers or on submarine highs as lag gravels; clays and invertebrate pastures occupied topographic lows on the sea floor.

Generally, conditions for life or for fossil preservation improved during deposition of sediments of the Mahantango Formation in Perry and adjacent counties. While the muds of the lower shale member were being laid down, conditions apparently were unsuitable for organisms; later, during deposition of the Montebello sands, some species, particularly psammophilic forms, flourished. Few shelled organisms other than brachiopods inhabited this sandy environment. Spiriferids, strophomenids, chonetids, and caramotoechiids were particularly abundant, and probably lay unattached on the shifting sands.

Although also dominated by brachiopods, the faunas of Bedford County contain a greater variety of species than those of Perry County and, therefore, may indicate more favorable environmental conditions. Early during deposition of the lower unit of siltstone of the Chaneysville Member, an extensive fauna developed in Bedford and Fulton Counties that was comparable to a similarly widespread coralline fauna in the Montebello Member of Perry County.

Sand and silts were deposited farther and farther westward, producing the Chaneysville and Backbone Ridge Members; gravel accumulated in parts of Perry County; and in Perry and Bedford Counties shells were concentrated in biostromes. Nearly all of the conglomerates are of local extent, but at least one is interpreted as representing a somewhat discontinuous blanket that covered much of Perry County perhaps reflecting maximum elevation of the source or maximum regression of the shoreline during deposition of the Mahantango Formation.

In Huntingdon County, the middle, coarser detrital sequence is composed of three members, in ascending order: the Backbone Ridge Siltstone Member, the Crooked Creek Shale Member, and the Donation Siltstone Member. Commencing with deposition of the Crooked Creek shale, a secondary transgression brought muds into the Huntingdon area. Shales in the middle of the Chaneysville Member in Bedford and Fulton Counties reflect this same subsidiary transgression. The culmination of mud deposition is represented in the Crooked Creek Member by the horizon of *Leiorhynchus multicostum,* a species normally associated with black shale faunas and, thus, indicative of conditions approaching those of the infraneritic zone. This secondary transgression was followed closely by another regressive phase which returned coarser clastics to the area. The micaceous siltstones of the Chaneysville and Donation Members were especially well suited for profuse development of orthids, spiriferids, and strophomenids.

Regression during deposition of the upper Montebello sands proceeded to such a degree that beds of hematite developed on top of the Montebello Member in parts of Perry County. In Perry County, the bed of hematite at the top of the Montebello marks a significant change in sedimentary conditions, but the origin of the hematite is not known.

Finally, during deposition of muds of the Frame Shale Member and upper shale member, conditions for organisms steadily improved. Toward the end of the Middle Devonian, the area received expansive deposits of mud and calcareous mud, and abounded in an assortment of invertebrates. With the introduction of Tully sediments into south-central Pennsylvania, the depositional history of the Mahantango Formation came to a close.

SUMMARY AND CONCLUSION

Field and laboratory studies of lithologic units and faunas indicate that the wedge of clastic sediments comprising the Mahantango Formation in south-central Pennsylvania may reliably be divided into three stratigraphic units, namely, the lower shale member or Gander Run Shale Member; the middle sequence of sandstone or siltstone and shale, termed the Montebello Member in Perry County, the Chaneysville Mem-

ber in Bedford and Fulton Counties, and the Backbone Ridge, Crooked Creek, and Donation Members in Huntingdon County; and the upper shale member or Frame Shale Member. The vertically contiguous units pass vertically and laterally into one another, representing facies of deposition. Inasmuch as the contact between the Marcellus Formation and the Gander Run Shale Member generally is gradational, it is inferred further that part of the lower Mahantango shale is time equivalent with part of the Marcellus black shale. The upper part of the Mahantango Formation interfingers, in places, with Tully sediments. Stratigraphic relationships of the Mahantango Formation are summarized in figure 8.

Faunas of the Mahantango Formation are dominated by brachiopod species, psammophilic species being confined, or nearly so, to the sandstone or siltstone facies. The distribution of species in the Mahantango Formation of south-central Pennsylvania is shown in table 6. Although many species also are present in the overlying and underlying formation, some, such as *Mediospirifer audaculus* and *Pustulatia pustulosa,* are distinctively Hamilton species. Study of the distribution of species, particularly their comparative abundance, provides faunal zonation useful for correlation and interpretation of paleoecologic conditions. Evidence for the neritic environment of deposition largely is drawn from the

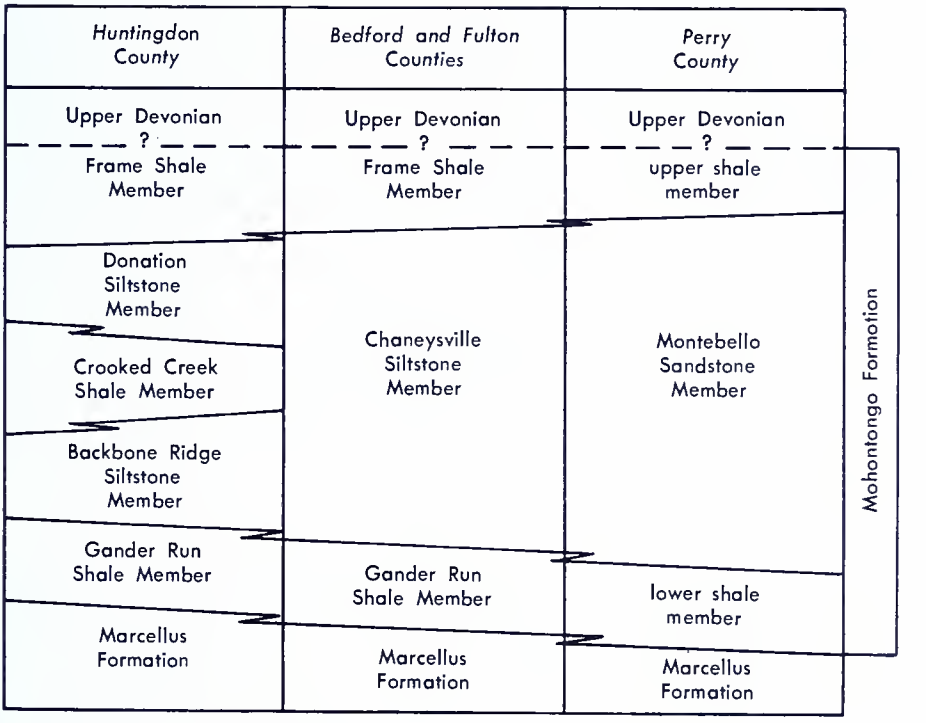


Figure 8. Summary of the stratigrophic relationships of the members of the Mahontango Formation of south-central Pennsylvania.

nature of the sediment and special features of sedimentation. However, to a limited extent, the evidence has been supplemented by faunal data.

Similar sequences of rocks and faunas in Pennsylvania and New York reflect similar tectonic histories and permit tentative correlation between the Hamilton units in these two areas. In addition, selected species have been used to demonstrate correspondences between horizons in the Mahantango Formation of Pennsylvania and in the Hamilton Group of New York.

SYSTEMATIC PALEONTOLOGY

INTRODUCTION

Most of the invertebrate species are described here. Species of most coelenterates, echinoderms, and plants are omitted. Other than crinoid columnals, only a few calical fragments of the genus *Technocrinus*? have been found. Mr. William A. Oliver, Jr., of the U. S. Geological Survey, kindly identified the numerous corals in the collection, and Mr. William Spackman, of the Pennsylvania State University, tentatively identified the single plant specimen discovered.

The descriptions of the species generally include the more diagnostic features only; new species, however, are fully described, and wherever possible, measurements also are recorded. The systematic paleontology is considered more thoroughly in the earlier work by the author (Ellison, 1961). For a general tabulation of specific occurrences, see table 6; for more detailed information on stratigraphic and geographic occurrence of species, see the descriptions of the sections in Appendix I.

DESCRIPTIONS

Phylum COELENTERATA

Class SCYPHOZOA

Subclass CONULATA

Genus CONULARIA

CONULARIA sp.

Pl. 4, fig. 1

Shell conical in outline, with longitudinal mid-line; apertural margin convex; length/width ratio 2.5.

Surface marked with transverse lirae that are convex toward aperture, unevenly spaced, and not of uniform development.

Measurements: length—15 mm; apertural width—6 mm.

Relationships.—Only a few of these forms have been collected in the present study area. Specimens generally show no more than a suggestion of transverse lirae. Absence of surface details renders specific identification impossible.

Class Anthozoa

Order Tabulata

Family Favositidae

Genus Pleurodictyum

Pleurodictyum styloporum (Eaton)

Pl. 4, fig. 2, 3

Astrea stylopora Eaton, 1832, p. 40, pl. 4, fig. 48.
Pleurodictyum stylopora Hall, 1876, pl. 18, fig. 1-9.
Pleurodictyum americanum Roemer, 1876, Leth. Geog., v. 1, Leth. Paleo., Atlas, pl. 28, figs. 2-2b.
Pleurodictyum styloporum Shimer and Shrock, 1944, p. 111, pl. 39, fig. 22-24. — Fenton and Fenton, in Stumm, 1950, card no. 352.

Corallum small, subhemispherical, composed of about 20 corallites radiating from a vermiform tube; upper surface convex, marked by the many subcircular calices.

Corallites subconical, range in diameter up to 4 mm, connected by numerous mural pores, with weak septal spines and ridges producing crenulate calices.

Relationships.—This species is recognized by its small size, subhemisperical form, and by the markedly crenulate surface in the calice.

Phylum Bryozoa

Order Cryptostomata

Family Fenestellidae

Genus Fenestella Lonsdale

Fenestella cf. F. emaciata Hall

Pl. 4, fig. 4-8

Fenestella emaciata Hall, 1881, v. 10. — Grabau and Shimer, 1909, v. 1, p. 143, fig. 199. — Shimer and Shrock, 1944. p. 263, pl. 29, fig. 26, 27.

Zoarium frondose with nearly parallel branches spaced 16 to 22 per 10 mm; dissepiments well developed, perpendicular to branches; fenestrules subelliptical and rhomboidal in outline, length about twice width, spaced 9 to 16 per 10 mm.

TABLE 6. *List of species and their occurrence in the Mahantango Formation of south-central Pennsylvania.*

(Numbers represent numbers of horizons in which species has been found in each member.)

Explanation of abbreviations:
GR—Gander Run Shale Member
M—Montebello Sandstone Member
F—Frame Shale Member
LS—Lower Shale Member
US—Upper Shale Member
C—Chaneysville Siltstone Member
BR—Backbone Ridge Siltstone Member
T—Tully Member, Harrell Formation
CC—Crooked Creek Shale Member
D—Donation Siltstone Member

Species	Perry Co.			Bedford Co.			Huntingdon Co.				
	LS	M	US	GR	C	F	GR	BR	CC	D	F
Phylum Coelenterata											
Conularia sp.	..	..	..	..	..	..	..	..	..	..	3
Stereolasma cf. *S. rectum* Hall	..	..	..	..	1	..	..	..	..	..	..
Stereolasma sp.	..	..	..	..	..	1	..	..	..	..	..
Stewartophyllum cf. *S. intermittens* (Hall)	..	..	..	..	..	..	..	..	..	..	2
Heterophrentis cf. *H. simplex* (Hall)	..	..	..	..	..	..	..	..	..	..	1
Heterophrentis? sp.	..	..	..	..	..	..	..	..	..	..	1
Heliophyllum halli Edwards and Haime	..	..	..	..	..	..	..	..	..	..	1
Blothrophyllum cf. *B. conatum*	..	..	..	..	..	..	..	..	..	..	1
"Cystiphyllum" cf. C. varians Hall	..	..	..	..	..	..	..	..	..	..	1
Cyathophylloid coral	..	..	..	..	..	1	..	..	..	..	..
Zaphrentoid coral	..	..	..	..	..	2	..	..	..	..	..
Favosites spp.	..	4	5	..	2	2	..	..	..	..	4
Thamnopora spp.	..	..	..	..	..	..	..	..	..	..	3
Pleurodictyum styloporum (Eaton)	..	3	1	..	3	2	..	1	..	1	..
Auloporoid corals	..	..	..	..	3	1	..	..	..	2	1
Phylum Bryozoa											
Fenestella cf. *F. emaciata* Hall, forms "A" and "C"	..	4	15	..	2	2	..	..	2	2	4
F. cf. *F. emaciata* Hall, form "B"	..	..	1	..	..	..	..	..	..	..	1
F. cf. *F. sinuosa* Hall	..	1	8	..	..	..	..	..	1	..	2
Anastomopora sp.	..	..	2	..	..	..	..	..	..	..	2
Polypora cf. *P. celsipora* (Hall)	..	..	..	..	..	..	..	..	..	..	2
Polypora sp.	..	1	3	..	..	..	..	..	..	..	2
Unitrypa sp.	..	..	..	..	..	..	..	..	..	..	1
Ptilopora sp.	..	..	1	..	..	..	..	..	..	..	..
Sulcoretepora cf. *S. incisurata* (Hall)	..	4	19	..	6	4	2	..	1	1	7
S. cf. *S. sinuosa* (Hall)	..	..	2	..	..	..	..	..	..	..	1
S.? sp.	..	..	..	..	..	..	..	..	..	..	1
Taeniopora exigua Nicholson	..	1	5	..	..	..	..	..	2	1	2
Paleschara radiata Hall	..	..	..	1	..	..	3	2	..	..	..
Fistuliporoid bryzoans	..	3	5	..	2	2	..	..	..	..	4
Bryozoan spp.	..	1	5	..	..	1	..	..	..	..	6
Phylum Brachiopoda											
Lingula delia Hall?	..	..	1	..	..	..	..	..	..	..	1
L. ligea Hall?	..	..	1	..	..	..	..	..	1?	..	..

L. spp.	1	1	..	..	..	2	..	..	..	..	..
Orbiculoidea doria (Hall)	..	..	..	..	2	2	..	..	..	..	2
O. tullia (Hall)?	..	..	1	..	..	..	..	..	..	..	..
Schizobolus concentricus (Vanuxem)	..	..	..	..	..	..	..	..	..	..	1
Petrocrania hamiltoniae (Hall)	..	..	1	..	..	2	..	..	..	..	..
Craniops hamiltonioe (Hall)	..	..	5	..	..	1	..	..	..	..	3
Rhipidomella leucosia (Hall)	..	..	3	..	..	..	..	..	..	..	..
R. pcnelopc (Hall)	..	3	..	..	..	..	..	..	..	..	..
R. vanuxemi (Hall)	..	..	6	..	3	4	..	..	2	3	2
Schizophoria sp.	..	..	..	..	1	..	..	..	..	..	..
Tropidoleptus corinotus (Conrad)	..	13	27	..	20	10	..	..	3	..	11
Centronella? sp.	..	..	1	..	..	..	..	..	..	..	..
Subrensselandia cloypolii (Hall)	..	2	..	..	..	..	..	..	..	..	..
Leiorhynchus limitare (Vanuxem)	..	..	1?	1	..	..	3	..	..	..	..
L. mesocostale Hall	..	..	T	..	..	..	..	..	..	..	T
L. multicostum Hall	..	..	..	..	..	..	..	..	1	..	..
L. sp.	..	..	1	..	..	1	..	..	..	..	..
Camarotoechia congregota (Conrad)	..	6	8	..	2	..	..	..	..	..	2
C. prolifica Hall	..	2	2	1	..	..	2	3	2	..	..
C. sappho Hall	..	..	1	..	1	..	..	..	1	1	1
C. spp.	..	1	4	..	..	..	..	1	..	..	1
Hypothyridina venustula (Hall)	..	..	..	..	..	..	..	..	..	..	T
Leptoena "rhomboidalis"	..	1	..	..	..	..	..	..	..	..	..
Schuchertella voriobilis Prosser and Kindle	..	3	13	..	4	2	..	..	1	3	8
Stropheodonta demissa (Conrad)	..	..	1	..	..	..	..	..	..	..	..
Megostrophia concava (Hall)	..	..	2	..	..	..	..	..	..	..	..
Protoleptostrophio perplana (Conrad)	..	3	13	..	5	8	..	1	1	1	10
Pholidostrophio pcnnsylvonica Kindle	..	..	3	..	..	..	..	..	1	1	..
Douvillina inocquistriota (Conrad)	..	..	7	..	..	..	..	..	1	..	2
D. inoequistriota var. *immoturo*, n. var.	..	..	11	..	..	..	..	..	..	1	6
"Chonctes" lepidus (Hall)	..	..	..	..	..	1	..	..	..	..	3
Devonochonctes coronatus (Conrad)	..	20	9	..	7	3	..	2	..	..	1
D. scitulus (Hall)	..	1	20	1	12	8	1	..	2	1	8
D. syrtolis (Conrad)	..	4	2	..	3	..	..	..	..	..	..
Retichonetes? aurora (Hall)	..	..	..	..	..	..	..	..	..	..	T
R. morylondicus (Prosser and Kindle)	..	2	1	..	11	..	..	..	1	..	..
R. vicinus (Castelnau)	..	..	2	..	3	1	..	..	..	..	1
Longispina mucronotus (Hall)	..	..	7	..	18	T	1	1	4	11	7
Productella spinulicosta (Hall)	..	..	4	..	..	1	..	2	..	..	..
Truncalosia truncota (Hall)	..	..	1	1	..	..	..	..	..	..	..
Atrypa rcticuloris (Linnaeus)	..	..	7, T	..	..	1	..	..	1	..	3
A. spinosa Holl	..	..	3	..	..	T	..	..	..	..	2
Pustulatio pustuloso (Hall)	..	..	12	..	1	..	..	..	1	..	2
Dclthyris sculptilis Hall	..	5	11	..	6	3	..	..	2	2	4
Elytho fimbriata (Conrad)	..	..	11	..	1	1	..	..	1	1	3
Emmanuella subumbona (Hall)?	..	..	T	..	..	..	..	..	..	..	T
E. pcnnsylvonico Willard	..	..	..	..	..	T	..	..	..	..	T
Porospirifer ocuminotus (Conrad)	..	2	..	..	..	..	..	..	..	..	..
Spinocyrtio gronuloso (Conrad)	..	2	6	..	1	4	..	..	2	2	..
S. gronulosa clintoni (Hall)	..	..	..	..	2	..	..	..	1	..	..
S. granuloso girtyi Ellison, n. spp.	..	6	1?	..	..	..	..	..	..	..	..
Mucrospirifer mucronotus (Conrad)	..	3	21	..	29	11	..	..	..	..	15

TABLE 6. *List of species and their occurrence in the Mahantango Formation of south-central Pennsylvania (continued).*

(Numbers represent numbers of horizons in which species has been found in each member.)

Species	Perry Co.				Bedford Co.			Huntingdon Co.			
	LS	M	US	GR	C	F	GR	BR	CC	D	F
Mediospirifer audaculus (Conrad)	..	3	11	..	6	4	1	2	2	1	3
M. audaculus macronotus (Hall)	..	1	..	..	1	1	..	..	..	..	..
M. bellitropis Ellison, n. sp.	..	4	..	..	..	..	..	..	..	..	..
M. dromgoldi Ellison, n. sp.	..	8	..	..	..	..	..	..	..	..	..
M. belliplicota Ellison, n. sp.	..	4	..	..	1	..	..	..	..	..	..
M. millerstownensis Ellison, n. sp.	..	4	..	..	..	..	..	..	..	..	..
M.? angustus (Hall)	..	..	..	..	..	..	..	..	..	1	..
Fimbrispirifer venustus (Hall)	..	..	..	..	1	..	..	..	..	..	..
Tylothyris pauliformis (J. S. Williams)	..	..	6	..	1	1, T	..	..	1	..	2
"Spirifer" tullius Hall	..	3	12	..	2	3	..	..	..	..	9
"Spirifer" spp.	..	5	4	..	4	..	..	..	..	1	1
Ambocoelia umbonata (Conrad)	..	..	2	..	2	3, T	..	..	2	..	4
Echinocoelia ambocoeloides Cooper and Williams	..	..	T	..	..	..	..	..	..	..	T
Cyrtina hamiltonensis (Hall)	..	1	..	..	2	..	..	..	..	..	4
Athyris spiriferoides (Eaton)	..	2	3	..	5	2	..	..	..	1	1
Phthonio sectifrons (Conrad)	..	..	1	..	..	..	..	..	..	1	
Phylum Mollusca											
Class Pelecypoda											
cf. Protomya oblonga (Hall)	..		..	..	1?			..	..	..	..
Orthonota undulata Conrad	..		6	1	..	1	..	..	1	..	4
O.? parvula Hall	..	..	4	..	..	..	..	..	..	..	..
Prothyris lanceolota Hall	..	..	..	..	..	..	2	1	..	..	..
Grammysia arcuata (Conrad)	..	..	..	..	..	..	..	..	..	..	2
Grammysioidea alveota (Conrad)	..	..	..	1	..	1	..	..	..	..	..
Tellinopsis subemorginata (Conrad)	..	..	2	..	..	1	..	..	..	..	..
Nucula lirota (Conrad)	..	..	1	..	..	1	..	..	..	..	..
N. bellistriota (Conrad)	..	..	11	..	3	4	1	..	..	..	4
N. varicosa Hall	..	..	2	..	1	..	..	..	..	..	..
N. spp.	..	..	1	..	1	1	..	..	..	..	..
Nuculites oblongatus Conrad	..	1	6	..	1	2	2	..	1	..	5
N. triqueter Conrad	..	..	4	..	1	..	..	..	..	..	4
N. sp.	..	..	..	..	..	..	..	..	..	..	1
Polaeoncilo muta Hall	..	1	12	..	1	1	..	..	..	..	2
P. emarginata (Conrad)	..	..	2	..	1	1	..	..	..	..	2
P. constricta (Conrad)	..	..	16	..	3	5	1	..	..	..	5
P. plana Hall	..	..	1	..	..	..	..	..	..	..	1
P. tenuistriata Hall	..	..	1	..	1	..	..	..	..	..	1
P. perplana Hall	..	..	1	..	2	..	1?	..	..	..	..
P. filosa (Conrad)?	..	..	1	..	..	..	..	..	..	..	..
P. fecunda (Hall)	..	..	1	..	1	1	..	..	..	..	..
Nuculana diversa (Hall)	..	..	2	..	1	..	..	..	..	..	..
Parallelodon hamiltonioe (Hall)	..	..	1	..	1	..	..	..	..	..	1
Cornellites flabella (Conrad)	..	4	4	..	7	..	..	..	..	..	..
Leiopterio laevis (Hall)	..	..	..	1	..	..	1	..	..	..	..

L. spp.	..	1	2	..	1	..	..	..	..	..	1
Glyptodesma erectum (Conrad)	..	..	..	..	2	..	..	..	..	..	..
Leptodesma rogersi Hall	..	..	..	2	..	..	2	1?	1	..	..
Pterochoenia frogilis (Hall)	..	..	3	..	..	..	1?	..	..	..	..
Actinopterio decussata (Hall)	..	2	7	..	5	1	..	1	..	..	5
Modiella pygmoea (Conrad)	..	..	2	..	..	..	..	..	..	..	..
Conocordium concinnum Hall	..	..	..	..	..	..	..	..	..	..	1
C. normole Hall?	..	..	..	..	..	..	1	..	..	..	..
Aviculopecten bellus (Conrad)	..	..	..	..	..	..	..	..	1	..	1
A. insignis Hall	..	..	..	..	..	..	..	..	..	..	1
A. equilotera (Hall)	..	..	1	..	..	..	..	..	..	..	..
Pterinopecten princeps (Conrad)	..	1	4	..	1?	2	..	..	..	..	1
P. hermes Hall?	..	..	2	..	..	..	..	..	..	..	..
Modiomorpha concentrica (Conrad)	..	..	6	..	5	3	..	..	1	..	1
Goniophora homiltonensis (Hall)	..	1?	2	..	1?	..	..	..	..	1?	1
Cypricardello bellostriata (Conrad)	..	..	8	..	..	..	..	..	1	..	2
C. tenuistriato (Hall)	..	..	3	..	..	1	..	..	..	..	..
Cypricordinia indenta (Conrad)	..	..	6	..	..	..	..	..	..	..	2
Porocyclos lirota (Conrad)	..	..	5	1	2	..	..	..	..	..	..
Class Gastropoda											
Ptomotis patulus (Hall)	..	1	..	..	2	..	..	..	..	..	..
Bucanopsis ledo (Hall)	..	..	1	..	..	4	..	..	..	..	3
Crenistriella crenistrio (Hall)	..	..	7	1?	2	1	..	..	..	..	1
cf. *Trepospiro rotalio* Hall	..	1	..	..	..	..	..	..	..	..	..
Bembexia sulcomorginoto (Conrad)	..	4	2	2	13	1	..	1	3	..	..
B. capillario (Conrad)	..	..	6	..	3	..	..	..	..	..	5
B. laevis Ellison, n. sp.	..	..	4	..	..	..	..	..	..	..	..
Mourlonio itys (Hall)	..	..	..	..	..	..	..	..	1	..	..
Loxonemo delphicolo Hall	..	1?	4	..	1	1	..	..	..	.	1
Holopea mocrostomus Hall	..	..	1	..	..	..	..	..	..		..
Cyclonemo sp.	..	1	2	..	..	1	..	..	..	..	2
Plotyceros (Orthonychia) conicum Hall?	..	..	..	..	..	..	..	..	..	..	T
Platyceros (Plotyostomo) cuompholoides Hall	..	..	2	..	..	..	..	..	..	..	..
Plotyceros (Plotyostomo) sp.	..	..	..	..	1	..	..	..	..	..	..
Platyceros sp.	..	..	..	..	1	..	..	..	..	..	..
Noticonemo linicoto (Conrad)	..	..	1	..	1	..	..	..	..	.	
Ionthinopsis? sp.	..	3	..	..	1	..	..	..	..	..	..
Gastropod spp.	..	..	5	1	2	1	..	..	..	..	..
Class Cephalopoda											
Striococeros typum (Saemann)?	..	..	..	..	..	..	..	..	..	..	1
Spyroceros nuntium (Hall)?	..	1	5	..	1	..	..	..	1	.	1
Michelinoceros? subulatum (Hall)	..	.	..	..	..	..	..	1	..	..	..
Orthocerid spp.	..	1	3	..	4	..	2	..	1	..	3
Boctrites? ociculum (Hall)	..	..	1	..	..	1	..	..	..	..	..
Class Pteropoda?											
Coleolus gracilis Hall?	..	..	1	..	..	2?	..	..	..	..	..
Coleolus sp.	..	..	..	..	..	..	..	..	..	..	1
Styliolino fissurella (Hall)	..	.	3	1	..	..	..	..	..	..	..
S. bellistriato Ellison, n. sp.	..	..	1	..	..	..	..	..	..	.	..
Tentaculites ottenuatus Hall	..	5	5	.	5	..	..	..	..		1

TABLE 6. *List of species and their occurrence in the Mahantango Formation of south-central Pennsylvania (continued).*

(Numbers represent numbers of horizons in which species has been found in each member.)

Species	Perry Co.			Bedford Co.			Huntingdon Co.				
	LS	M	US	GR	C	F	GR	BR	CC	D	F
Phylum Arthropoda											
Class Trilobita											
Proetus rowi (Green)	..	..	..	..	..	..	..	..	..	..	3
Dechenella macrocephala (Hall)	..	..	1	..	..	..	..	..	2	..	1
Phacops rana (Green)	..	1	12	..	1	2, T	..	..	..	..	7
Grecnops boothi (Green)	..	..	9	..	1	3	..	1	1	..	5
G. boothi var. *callitcles* (Green)	..	..	2	..	..	..	..	..	..	..	2
Trimerus (Dipleura) dekayi Green	..	7	10	..	5	3	..	1	..	..	6
Class Crustacea											
Hollinella tricollina (Ulrich)	..	1	..	..	..	..	..	..	..	..	1
H. cf. *H. sella* Stover	..	..	4	..	1	..	..	..	..	..	1
H. sp.	..	..	1	..	..	..	..	..	..	..	4
Adelphobolbina mcdialis Stover	..	..	3	..	..	1	..	..	..	..	4
Ctenoloculina cicatricosa (Warthin)	..	..	2	..	..	1	..	..	..	..	1
Ulrichia spinifera Coryell and Malkin?	..	..	3	..	..	..	..	..	..	..	1
Ulrichia sp.	..	..	1	..	..	..	..	..	..	..	..
Hibbardia lacrimosa (Swartz and Oriel)	..	..	5	..	..	1	..	..	1	..	3
Ponderodictya punctulifera Hall	..	..	3	..	..	1	..	..	..	..	1
Octonaria bifurcata Stover	..	..	1	..	..	..	..	..	..	..	..
Euglyphella numismoides Swartz and Oriel	..	..	2	..	..	..	..	..	..	..	..
E. sp.	..	..	..	..	..	..	..	..	..	..	3
Quasillites sp.	..	..	1	..	..	..	..	..	..	..	..
Bufina sp.	..	..	1	..	..	..	..	..	..	..	..
Ostracode spp.	..	..	4	..	..	1	..	..	..	..	..
Schizodiscus capsa Clarke	..	..	2	..	..	..	..	..	..	..	..
Phylum Echinodermata											
Technocrinus? sp.	..	..	..	..	..	..	..	..	..	..	1
Crinoid columnals	..	8	30	..	15	4	1	1	3	4	8

Front with 2 ranges of zooecia; zooecia subrectangular or subtrigonal in outline, spaced 18 to 22 per 5 mm, continue uninterrupted across junctions of dissepiments; apertures with well developed peristomes; carinae weak.

Back longitudinally striate.

Relationships.—Fenestella emaciata is a common species in the Hamilton Group of New York. In its typical form, it is funnel- or fan-shaped and has a well developed carina. Specimens in this collection possess only a weakly developed carina, and lack spines on the back. Nevertheless, these specimens most closely resemble *F. emaciata,* although they are similar also to *F. cooperi* McNair (1942, p. 344). Three different forms of this species have been recognized, on the basis of zooecial outline and spacing of fenestrules and zooecia. Forms A and C of *Fenestella* cf. *F. emaciata* have subrectangular zooecia, whereas form B has subtrigonal to subrhomboidal zooecia. These forms, however, lack stratigraphic separation, and, therefore, are not regarded as separate species or subspecies. Elias (1957, p. 62) has noted that even within a single specimen, the spacing of fenestrules and zooecia may vary markedly.

Fenestella cf. F. sinuosa Hall

Pl. 4, fig. 9

Fenestella sinuosa Hall, 1886, expl. pl. 44, fig. 5, 6. — Hall and Simpson, 1887, v. 6, p. 116, pl. 44, fig. 5, 6.

Zoarium frondose, with 14 to 15 branches per 10 mm; branches sinous and anastomose so that dissepiments are little more than intersections of branches; dissepiments depressed; fenestrules subelliptical to ovate in outline, 6 to 7 per 5 mm, length more than twice width.

Front with 2 ranges of zooecia which number 16 to 18 per 5 mm; zooecia not interrupted at dissepiments; apertures with peristomes; carinae very high and narrow, at least at base.

Back of species not recognized.

Relationships.—Fenestella cf. *sinuosa* is a rather common form in the Mahantango Formation, and can be recognized by the striking sinuosity of the branches, and by the high carinae. Although *F. sinuosa* is described by Hall (1887) as a species of the Helderberg, specimens from the Mahantango Formation in south-central Pennsylvania resemble it more closely than any other.

Genus Polypora McCoy

Polypora cf. P. celsipora (Hall)

Pl. 4, fig. 10

Fenestella celsipora Hall, 1881, v. 10, abstract, p. 24. *Fenestella (Polypora) celsipora* Hall and Simpson, 1887, v. 6, p. 150, pl. 41, fig. 16-22; pl. 42, fig. 5-10.

Zoarium frondose with branches spaced 12 per 10 mm; branches anastomose; dissepiments formed by intersection of branches, depressed; fenestrules range considerably in form, more or less elliptical, length from 2 to 4 times width, spaced 5 per 10 mm.

Front with 3 or 4 ranges of zooecia which number 15 to 16 per 5 mm; zooecia continue uninterrupted across junctions of dissepiments; apertures with peristomes; carinae fine, separate zooecial ranges.

Back not recognized.

Relationships.—This species of *Polypora* is distinguished by its fine, linear carinae which separate zooecial ranges.

Polypora sp.

Pl. 4, fig. 11

Zoarium frondose with subparallel branches numbering about 10 per 10 mm; dissepiments well developed and approximately perpendicular to branches; fenestrules subelliptical to subquadrate in outline, length about twice width, numbering 10 per 10 mm.

Front with zooecia commonly in 4 ranges and numbering 10 per 5 mm; zooecia continues across dissepimental junctions; apertures with peristomes; carinae absent or very indistinct.

Back not recognized.

Relationships.—These specimens, although similar in many respects to those referred to *Polypora* cf. *P. celsipora,* differ from the latter in having more ranges of zooecia, smaller fenestrules, and no carinae between zooecial ranges.

Genus Unitrypa Hall

Unitrypa sp.

Pl. 4, fig. 12

Zoarium frondose with reticulate superstructure; branches subparallel, number 18 to 19 per 10 mm; fenestrules rhombic to elongate-elliptical in outline, length about 3 times width, 10 per 10 mm; dissepiments well defined, carinate, oblique to branches.

Front with zooecia in two ranges; zooecia small, numbering 18 to 19 per 5 mm, rhombic in outline; crossbars form superstructure, number 15 to 16 per 5 mm, somewhat obliquely disposed to longitudinal branches formed by elevation and expansion of carinae.

Back not recognized.

Relationships.—Only one specimen that can definitely be referred to this genus has been identified. However, were it not for the superstructure, this specimen would be almost indistinguishable from *Fenestella* cf. *F. emaciata*. Specimens in which the superstructure is not preserved may be recognized by the carinate nature of the dissepiments.

Family Sulcoretеporidae

Genus Sulcoretepora Orbigny

Sulcoretepora cf. S. incisurata (Hall)

Pl. 5, fig. 1-3

Stictopora incisurata Hall, 1881, v. 10, p. 189. — Hall and Simpson, 1887, v. 6, p. 241, pl. 60, figs. 1-18.

Cystodictya incisurata Grabau and Shimer, 1909, v. 1, p. 160, fig. 211.

Sulcoretepora incisurata Shimer and Shrock, 1944, p. 270, pl. 102, fig. 16, 17.

Zoarium ribbon-like, bifoliate so that both sides are identical, isotomously ramose; branches flattened lenticular in cross-section, measure 2 to 4 mm wide, with subparallel margins.

Zooecia disposed in longitudinal ranges, spaced 9 per 5 mm, subelliptical to nearly circular in outline; ranges number 7 to 10 in width of a branch, increase by bifurcation; peristomes and lunaria prominent; longitudinal ridges between ranges straight and continuous, diverging slightly to intersect margins.

Internally, zooecia are very elongate-sigmoidal in outline producing symmetrical pattern; zooecia recumbent against mesotheca throughout most of their length; mesothecae with arcuate, transverse rugae which are impressed on inner recumbent portions of zooecia; striae longitudinal, slightly divergent in mesothecae, mark dividing lines between zooecia.

Relationships.—Specimens referred to this species are most easily confused with *S. gilberti* found in the Helderberg, but that species has broader branches that are fewer in number and have less straight margins. The straight, continuous ridges separating zooecial ranges serve to distinguish this species from many other similar species in which the ridges are discontinuous and, in many cases ornamented with nodes.

Sulcoretepora cf. S. sinuosa (Hall)

Pl. 5, fig. 4

Stictopora sinuosa Hall, 1881, v. 10, p. 190. — Hall and Simpson, 1887, v. 6, p. 247, pl. 61, fig. 17.

Zoarium ribbon-like, bifoliate so that both sides are identical, isotomously ramose; branches flattened lenticular in cross-section, measure 2 to 5 mm wide, with subparallel margins.

Zooecia more or less randomly disposed, numbering 7 to 11 per 5 mm, subcircular in outline; space between zooecia marked with low, sinuous, interrupted ridges.

Internally, zooecia are elongate tubes, recumbent throughout most of their length and impressed against a rugose mesotheca; mesotheca with arcuate, transverse ruga which are impressed on inner recumbent portions of zooecia; longitudinal striae in mesotheca.

Relationships.—These specimens are very similar to those referred to *Sulcoretepora* cf. *S. incisurata* except for their somewhat broader branches and the characteristically sinuous, interrupted ridges in the interspaces between zooecia. That species is considerably more abundant, and, since both occur together stratigraphically, *S.* cf. *S. sinuosa* may prove to be only a variant of *S.* cf. *S. incisurata.* The specimens of this species having narrower branches generally are more intricately ornamented, the interrupted ridges becoming almost nodose; specimens with broader branches have fewer and weaker sinuous ridges.

Sulcoretepora? sp.

Pl. 5, fig. 4, 5

Zoarium ramose; branches hollow, 4 mm wide and 2 mm thick.

Internally, three distinct layers are present: inner mesotheca longitudinally furrowed, surrounds hollow axis; hypostructure adjacent to mesotheca, consists of irregularly disposed walls forming polygonal chambers; outer zooecial layer supported by hypostructure, with 7 to 10 zooecial ranges separated by fine, longitudinal ridges as in *Sulcoretepora.*

Relationships.—The relationship between the hypostructural chambers and the true zooecia has not been determined. Nevertheless, this species is unlike any bryozoan previously described in the literature. *Coelocaulia* and *Glossotrypa* (Hall, 1887) both have hollow axes, but the diameter of the axis is much smaller in these genera than in this species and neither of these two genera has the outward appearance of *Sulcoretepora.* On the other hand, no species of *Sulcoretepora* has been described with a hollow axis and a hypostructure such as that possessed

by these specimens; these two features, however, may be related to the type of preservation, and not represent true taxonomic features. In spite of the differences, apparent or real, it has been considered advisable to assign this species to the genus *Sulcoretepora,* with reservation, until the species is better understood.

Genus Taeniopora Nicholson

Taeniopora exigue Nicholson

Pl. 5, fig. 7

Taeniopora exigue Nicholson, 1874, v. 1, p. 120. — Hall, 1881, v. 10, p. 192. — Hall and Simpson, 1887, v. 6, p. 263, pl. 62, fig. 15-26. Nicholson, 1895, p. 533, pl. 11, fig. 12-16; pl. 12, fig. 1-6. — Grabau and Shimer, 1909, v. 1, p. 161, fig. 212. — Shimer and Shrock, 1944, p. 270, pl. 102, fig. 25, 26.

Zoarium ramose, pinnately branching, bifoliate; branches measure 2 to 3 mm in width, nearly in apposition, strongly carinate.

Zooecia in 3 to 5 ranges on either side of carina, small, numbering 10 to 15 per 5 mm; zooecia nearest carina are smallest and most closely spaced; internally, zooecia are quadrilateral in outline and wrinkled from impression against transversely rugose mesotheca.

Relationships.—This distinctive species is recognized by its strongly carinate, pinnate branches, each with several ranges of zooecia on either side of the carina.

Family Paleschariidae

Genus Paleschara Hall

Paleschara radiata Hall

Pl. 5, fig. 8

Paleschara? radiata Hall, 1879, p. 160. — Hall and Simpson, 1887, v. 6, p. 35, pl. 16, fig. 13, 14.

Zoarium very small, circular, plate-like, measuring from 2.5 to 4.5 mm in diameter.

Apertures elongate, diamond-shaped, contiguous, approximately 0.25 mm wide and 0.4 mm long, arranged radially in rosette pattern giving zoarium the appearance of a minute, flattened, many-petalled flower.

Relationships.—This species, unlike *P. incrustans* and others, is readily recognized by its very small size, circular outline, and rosette pattern of the apertures. It is represented in this collection by innumerable external molds, chiefly from the Marcellus shale and the Gander Run Member of the Mahantango Formation. These forms are reported to be encrust-

ing bryozoans, but no specimens in this collection are obviously attached to other shells.

Phylum Brachiopoda

Class Inarticulata

Order Atremata

Superfamily Lingulacea

Family Lingulidae

Genus Lingula Bruguiere

Lingula delia Hall?

Pl. 6, fig. 1, 2

Lingula delia Hall, 1863, p. 22. — Hall, 1867, p. 12, pl. 2, fig. 9. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 125, pl. 8, fig. 5.

Pedicle valve medium in size, subelliptical to subquadrangular in outline, biconvex; anterior and posterior margins regularly to sharply rounded; lateral margins subparallel and very broadly rounded; viewed anteriorly valve is subcarinate. Surface bears concentric striae, and very fine, wrinkled concentric lirae.

Pedicle valve: length—21 mm; width—12 mm; convexity—3.5 mm.

Relationships.—Lingula delia is represented in this collection by one complete pedicle valve, and one fragmental valve. This species differs from other species of *Lingula* known in the Mahantango Formation in its more quadrangular outline, more ventricose profile, and larger size. The single complete pedicle valve, however, shows very fine, wrinkled, concentric ornament, a characteristic considered by Hall (1867, p. 11) to be distinctive of *L. nuda*. The narrow, flange-like border of the complete pedicle valve in this collection is not mentioned by Hall as a characteristic of *L. delia*. In spite of these differences, the two specimens in this collection are assigned to *L. delia*, but with reservation.

Lingula ligea Hall?

Pl. 6, fig. 3

Lingula ligea Hall, 1860, p. 76. — Hall, 1867, p. 7, pl. 1, fig. 2. — Grabau and Shimer, 1909, p. 197, fig. 229 d. — Prosser and Kindle in Prosser, Kindle, and Swartz, 1913, p. 126, pl. 8, fig. 6.

Brachial? valve small elongate-ovate in outline, nearly flat; anterior margin regularly rounded to subtruncate; lateral margins broadly rounded and converging acutely at beak; narrow rim produced by slight flattening of periphery.

Surface bears fine concentric lirae, crowded into bands to form more distantly spaced concentric undulations.

Brachial? valve: length—14 mm; width—8 mm; convexity—0.5 mm.

Relationships.—The elongate-ovate outline, radial and concentric ornament, and the narrow marginal rim of this specimen warrant its being referred tentatively to *Lingula ligea.*

Lingula? sp.

Pl. 6, fig. 4

Valve large, moderately convex, weakly sulcate toward anterior margin, broadly ovate in outline with greatest width two-thirds distance forward of beak; viewed anteriorly, valve is broadly rounded; beak obtuse; postero-lateral margin slightly flattened, producing a narrow rim.

Surface bears poorly defined concentric striae and few, indistinct concentric undulations.

Shell microstructure is lamellar.

Valve: length—26 mm; width—26 mm; convexity—7 mm.

Relationships.—The lamellar microstructure of the shell is definitely a lingulid feature, but the combined size and ovate outline of this specimen make it unlike any described species of *Lingula.* The author has been unable to determine whether the specimen is a pedicle or a brachial valve.

Order Neotremata
Superfamily Discinacea
Family Discinidae
Genus Orbiculoidea Orbigny

Orbiculoidea doria (Hall)

Pl. 6, fig. 5, 6

Discina doria Hall, 1863, p. 26. — Hall, 1867, p. 19, pl. 2, fig. 19-22, 31. *Orbiculoidea doria* Schuchert, 1897, p. 278.

Shell small, convexi-plane, subcircular to ovate in outline.

Pedicle valve flat; apex nearly at middle of valve, not elevated; foramen in expanded slit extending from apex to posterior margin.

Brachial valve subconical; apex subterminal and posteriorly directed; circular to prolate in outline.

Surface of pedicle valve bears numerous, evenly and widely spaced concentric lirae; surface of brachial valve nearly smooth in all but one specimen, which has widely spaced concentric lirae between which are several finer lirae.

Brachial valve: length—3.5 to 12 mm; width—3 to 9 mm; convexity—1.0 to 2.5 mm.

Relationships.—Orbiculoidea doria is recognized primarily by its subterminal apex and, to a lesser extent, by its circular to prolate outline. *Craniops hamiltoniae* is similar to this species in general outline and profile, but *C. hamiltoniae* is not chitinophosphatic and has prominent concentric lirae, whereas only the pedicle valve of *O. doria* has concentric ornament. One specimen of *O. doria* in this collection has faint radial folds, a feature relating to *O. lodiensis* var. *media*.

Orbiculoidea tullia (Hall)?

Pl. 6, fig. 7

Discina tullia Hall, 1863, p. 28. — Hall, 1867, v. 4, p. 22, pl. 2, fig. 16, 17.
Orbiculoidea tullia Schuchert, 1897, p. 282.

Brachial valve small, subconical in profile, subelliptical in outline; apex one-third distance forward of posterior margin; lateral margins only slightly flattened.

Surface bears numerous, unevenly disposed, concentric lirae.

Brachial valve: length—11 mm; width—8 mm; convexity—2 mm.

Relationships.—The fragmentary nature of the single specimen makes identification tenuous. The specimen has been assigned to *O. tullia* on the basis of its subelliptical outline, and unevenly disposed concentric lirae.

Genus Schizobolus Ulrich

Schizobolus concentricus (Vanuxem)

Pl. 6, fig. 8

Lingula concentrica Vanuxem, 1842, p. 168, fig. 4.
Discina truncata Hall, 1863, p. 28. — v. 4, p. 23, pl. 1, fig. 15; pl. 2, fig. 36, 37.
Schizobolus truncatus Hall and Clarke, 1892, v. 8, pt. 1, p. 87, pl. 3, fig. 11-14.
Schizobolus concentricus Schuchert, 1897, p. 372. — Grabau and Shimer, 1909, v. 1, p. 203, fig. 237. — Cooper, in Shimer and Shrock, 1944, p. 291, pl. 109, fig. 19-21.

Pedicle valve small, depressed convex, ovate in outline; posterior margin notched adjacent to foramen; apex eccentric toward posterior; foramen narrow.

Surface bears evenly, but widely spaced concentric lirae.

Relationships.—This species is represented in this collection by one imperfectly preserved pedicle valve, but the ovate outline and notched posterior margin serve to distinguish it from other similar species.

Superfamily CRANIACEA

Genus PETROCRANIA Raymond

PETROCRANIA HAMILTONIAE (Hall)

Pl. 6, fig. 9, 10

Crania hamiltoniae Hall, 1860, p. 77, fig. 4, 5, on p. 76. — Hall, 1867, p. 27, pl. 3, fig. 17-23. — Hall and Clarke, 1892, pl. 41, fig. 3-16.
Craniella hamiltoniae Schuchert, 1897, p. 193. — Grabau and Shimer, 1909, p. 208, fig. 244, 1, 2. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 131, pl. 9, fig. 1-7.
Petrocrania hamiltoniae Cooper, in Shimer and Shrock, 1944, p. 291, pl. 109, fig. 28-30.

Shell calcareous, endopunctate.

Brachial valve small to medium in size, irregularly ovate in outline, moderately convex; margins somewhat flattened, producing narrow rim.

Interior of brachial valve with two pairs of small, subelliptical muscle scars, one pair more or less apical in position and one pair marginal in position; *pi*-shaped markings also at both ends of one specimen.

Brachial valve: length—9 to 20 mm; width—12 to 20 mm; convexity—4.5 to 7 mm.

Relationships.—*Petrocrania hamiltoniae* is represented in collection by several brachial valves, largely internal molds, and some with traces of shell material. As originally described by Hall (1860), specimens of this species generally are found attached to other shells. Specimens in the present collection, however, are not attached to identifiable shells.

Genus CRANIOPS Hall

CRANIOPS HAMILTONIAE (Hall)

Pl. 6, fig. 11, 12

Pholidops hamiltoniae Hall, 1860, p. 92. — Hall, 1867, p. 32, pl. 3, fig. 6-9. — Hall and Clarke, 1892, p. 157, pl. 41, fig. 31-34. — Schuchert, 1897, p. 306. — Grabau and Shimer, 1909, p. 209, fig. 245. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 132, pl. 9, fig. 8.
Craniops hamiltoniae Cooper, in Shimer and Shrock, 1944, p. 293.

Shell very small, ovate to subelliptical in outline, depressed biconvex, concentrically lamellose.

Interior of pedice valve with margins deflected or thickened, producing a peripheral platform; muscle scar apical and elevated, circular in outline, trisected by Y-shaped furrows.

Interior of brachial valve like that of pedicle valve except that muscle scar is crescent-shaped elevation that is convex anteriorly.

Relationships.—Craniops hamiltoniae is distinguished from *C. areolata* by its smaller size and more ovate outline. Specimens of *C. hamiltoniae,* however, vary markedly in outline; brachial valves commonly are more elliptical and less ovate than pedicle valves.

Class Articulata

Order Orthida

Superfamily Dalmanellacea

Family Rhipidomellidae

Genus Rhipidomella Oehlert

Rhipidomella leucosia (Hall)

Pl. 6, fig. 13, 14

Orthis leucosia Hall, 1860, p. 80. – Hall, 1867, p. 48, 63, pl. 7, fig. 4.
Rhipidomella leucosia Hall and Clarke, 1892, p. 225, pl. 6, fig. 16; pl. 6A, fig. 9. — Grabau and Shimer, 1909, p. 265, fig. 320 d, e. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 166, pl. 14, fig. 1-5.

Shell large, broadly subovate in outline, biconvex, costellate; greatest width three-fourths distance forward of beak.

Pedicle valve depressed convex.

Brachial valve moderately convex; greatest convexity equals 0.28 of greatest length; viewed anteriorly, valve is regularly convex and slightly flattened to sulcate medially; length/width ratios for 2 specimens average 0.87.

Surface bears many subequal costellae which are broader than intervening furrows and number 3 per mm at middle of anterior margin; increase by bifurcation; few concentric lamellae near anterior margin; fine punctae and tubules open along costellae.

Brachial valve: length—23 mm; width—26 to 27 mm; convexity— 6 to 7 mm.

Relationships.—Rhipidomella leucosia is differentiated from *R. vanuxemi* primarily on the basis of its more ovate outline with somewhat more pointed posterior, and its greater brachial convexity. In this collection, *R. leucosia* is stratigraphically distinct from *R. vanuxemi,* and has been found only in Perry County. Recognizable pedicle valves not adequately represented in this collection.

Rhipidomella penelope (Hall)

Pl. 6, fig. 15-18

Orthis penelope Hall, 1860, p. 79, fig. 1, 2. — Hall, 1867, p. 34, pl. 4, fig. 1, 8-10.

Rhipidomella penelope Hall and Clarke, 1892, p. 225, pl. 6A, fig. 6. — Grabau and Shimer, 1909, p. 265, fig. 320, f-g. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 167, pl. 14, fig. 6-9. — Cooper, in Shimer and Shrock, 1944, p. 355, pl. 139, fig. 21-23.

Shell large, oblate in outline, plano-convex, costellate; greatest width at middle of shell; cardinal extremities obtuse and rounded.

Pedicle valve nearly flat to depressed convex; greatest convexity equals 0.11 of greatest length, located 0.24 distance forward of beak; viewed anteriorly, valve is broadly flattened, becoming more convex toward middle of valve; length/width ratios for 2 specimens average 0.93; beak extends slightly behind hinge.

Brachial valve depressed convex; greatest convexity equals 0.16 of greatest length, located 0.32 distance forward of beak; viewed anteriorly, valve is regularly convex, becoming more sharply convex toward middle of valve; length/width ratio for 1 specimen is 1.05; beak scarcely extends behind hinge.

Surface bears many fine, rounded costellae that number 7 per 4 mm at middle of anterior margin; concentric lamellae widely spaced in marginal half of shell.

Pedicle valve: length—27 to 32 mm; width—29.5 to 34 mm; convexity—3.0 to 3.5 mm.

Relationships.—Rhipidomella penelope is represented in this collection by numerous pedicle valves, but only one incompletely preserved brachial valve. This species differs from *R. vanuxemi* in its larger size, and more oblate and less ovate outline. Unfortunately, the best specimens of *R. vanuxemi* in this collection are brachial valves, whereas the best specimens of *R. penelope* are pedicle valves. This renders it difficult to make comparisons of the structures that Weller (1914) considers distinctive for species of *Rhipidomella*, i.e. cardinal process, socket plates, and musculature. Hall (1867, p. 51) states that the tubular character of the striae is most prominent in *R. penelope*, but external ornament is poorly preserved in specimens in this collection.

Rhipidomella vanuxemi (Hall)

Pl. 6, fig. 19-25

Orthis vanuxemi Hall, 1857, p. 135, fig. 1-7. — Hall, 1867, p. 40, 47, pl. 5, fig. 6; pl. 6, fig. 3.

Rhipidomella vanuxemi Hall and Clarke, 1892, p. 225, pl. 6, fig. 14, 15; pl. 6A, fig. 7, 8. — Grabau and Shimer, 1909, p. 265, fig. 320, a-c. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 165, pl. 13, fig. 26-29.

Shell small to large in size, subcircular in outline, biconvex, costellate; greatest width between one-half and three-fourths distance forward of beak.

Pedicle valve moderately convex; greatest convexity 0.24 of greatest length, located one-third distance forward of beak; length/width ratios for 5 specimens average 0.93.

Brachial valve moderately convex; greatest convexity 0.26 of greatest length, located 0.42 distance forward of beak; length/width ratios for 9 specimens average 0.90.

Surface bears over 100 subequal, rounded costellae; costellae as broad as intervening furrows, number 3 per mm at middle of anterior margin; increase by intercalation and bifurcation; costellae reflected posteriorly at lateral margins; some specimens have growth lamellae near anterior margin.

Pedicle valve: length—18.0 to 21.5 mm; width—19.5 to 23.0 mm; convexity—4 to 5 mm.

Relationships.—The three species of *Rhipidomella* common in the Hamilton Group of New York are *R. vanuxemi*, *R. leucosia*, and *R. penelope*. Of these three, *R. leucosia* is comparatively rare. According to Hall (1867, p. 51), the three species are rather similar, and may be difficult to separate. In outline, *R. penelope* is most nearly circular, and *R. leucosia* most strikingly ovate. Furthermore, *R. penelope* commonly is larger, and has a less convex pedicle valve and more strongly defined muscle scars than *R. vanuxemi*. *R. leucosia* is more gibbous than *R. vanuxemi*. The tubular openings mentioned by Hall with regard to *R. vanuxemi*, but stressed with regard to *R. penelope* are common in specimens of *R. vanuxemi* in this collection.

Several smaller than average specimens were collected from the 928-foot horizon at Bedford, along with specimens of normal size. It is believed that these are but immature forms of *R. vanuxemi* rather than another species, such as *R. cyclas*. The general features of these specimens agree with those of *R. vanuxemi;* the tubular openings are especially well defined.

Family TROPIDOLEPTIDAE

Genus TROPIDOLEPTUS Hall

TROPIDOLEPTUS CARINATUS (Conrad)

Pl. 7, fig. 1-15

Strophomena carinata Conrad, 1839, p. 64.

Tropidoleptus carinatus Hall, 1857, p. 151, fig. 1, 2. — Rogers, 1858, p. 828, fig. 672. — Hall, 1867, p. 407, pl. 62, fig. 2, 3. — Hall and Clarke, 1893, p. 304, fig. 227, 228, pl. 82, fig. 26-36. — Grabau and Shimer, 1909, p. 305, fig. 382. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 181, pl. 16, fig. 7-14. — Cooper, in Shimer and Shrock, 1944, p. 359, pl. 140, fig. 19-20.

Shell small to medium in size, concavo- to plano-convex, semi-elliptical in outline; greatest width slightly larger than greatest length, and difference increases with size; hinge equal to or slightly less than greatest width; surface plicate.

Pedicle valve subcarinate and moderately convex; greatest convexity 0.25 of valve length; length/width ratios for 5 specimens average 0.90; delthyrium broadly triangular, open.

Brachial valve concave or flat with greatest concavity located more than one-half distance forward of beak.

Surface of valves bears 16 to 26 coarse, angular to subangular radial plications which become indistinct on cardinal angles; concentric growth lines closely spaced near margins of larger individuals.

Interior pedicle valve bears well defined, divergent, crenulated teeth supported by short lamellae.

Interior brachial valve bears crenulated dental sockets bounded medially by hinge plate and short crura; cardinal process bulbous with bilobate myophore.

Pedicle valve: length—6.0 to 18.0 mm; width—7.0 to 22.0 mm; convexity—2.0 to 4.0 mm.

Relationships.—Tropidoleptus carinatus differs from all other species in the Mahantango Formation in general appearance, particularly its subcarinate profile and plicate ornament, and also in its distinctively crenulated teeth and associated teeth sockets.

This is one of the most ubiquitous species in the Mahantango Formation in southern Pennsylvania, both stratigraphically and geographically. Study of intraspecific variation of this species would undoubtedly yield results useful in stratigraphic correlation and faunal zonation.

Order Terebratulida

Superfamily Terebratulacea

Family Stringocephalidae

Subfamily Rensselandiinae

Genus Subrensselandia Cloud

Subrensselandia claypolii (Hall)

Pl. 6, fig. 28-31

Newberrya claypolii Hall, 1891, p. 9, pl. 5, fig. 1-9. — Hall and Clarke, 1893, p. 263, pl. 78, fig. 1-9.

Subrensselandia claypolii Cloud, 1942, p. 93, pl. 13, fig. 1-8. — Cooper, in Shimer and Shrock, 1944, p. 364, pl. 142, fig. 8, 9.

Shell medium to large in size, obovate in outline, biconvex, smooth; greatest width less than one-fourth distance forward of beak.

Pedicle valve moderately convex; greatest convexity equals 0.30 of valve length, located 0.37 distance forward of beak; length/width ratios for 3 specimens average 1.19; delthyrium triangular, wider than high, open.

Brachial valve moderately convex, but less than that of pedicle valve; length/width ratios for 2 specimens average 1.12; beak extends behind hinge somewhat less than that of pedicle valve.

Surface smooth, but bearing faint concentric growth lamellae.

Interior pedicle valve with teeth supported by dental plates that originate from the postero-lateral margins and lie in planes sub-parallel with and beneath the interarea; adductor scars narrow, elongate, bounded by diductor scars; diductor scars small, deeply excavated, "snow-shoe-shaped", flanked postero-laterally by adjustor scars; adjustor scars divergent, shallower than diductor scars; several fine pallial sinuses extend from anterior and lateral margins of muscle areas to anterior margin of valve.

Interior brachial valve with discrete flat, triangular hinge plates supported by crural plates and separated by crural trough; tooth sockets narrow, elongate, lie along cardinal margin; muscle scars in central half of valve, strongly or faintly marked; pallial sinuses originate at posterior margin of muscle area, extend to anterior margin of valve.

Pedicle valve: length—21.0 to 35.0 mm; width—19.0 to 28.0 mm; convexity—7.0 to 8.5 mm.

Relationships.—Subrensselandia claypolii is distinguished by its hinge plates with crural supports on the brachial valve. The character of the muscle areas, open delthyrium, and general obovate outline are also distinctive. Cloud's types (1942) came from nearly the same stratigraphic and geographic position as specimens in this collection. Specimens measured by Cloud (1942, p. 94) and illustrated (pl. 13, fig. 3, 4) are more elongate than the specimens in this collection.

Genus Centronella

Centronella? sp.

Pl. 6, fig. 26, 27

Pedicle valve subcircular in outline; beak only slightly extended posteriorly; cardinal slopes form 115 degrees angle at beak.

Surface smooth except for two weakly developed concentric rugae in outer third of valve.

Measurements: length—11 mm; width—11 mm; convexity—3 mm.

Relationships.—Centronella? sp. is represented in this collection by an internal mold and an external mold of one individual from New Bloomfield and one specimen from Rockville. The tentative identification is based on the subcircular outline and on the smooth surface with weak concentric ornament.

Order RHYNCHONELLIDA

Superfamily RHYNCHONELLACEA

Family CAMAROTOECHIIDAE

Genus LEIORHYNCHUS Hall

LEIORHYNCHUS LIMITARE (Vanuxem)

Pl. 7, fig. 16, 17

Orthis limitaris Vanuxem, 1842, p. 146, fig. 3.

Leiorhynchus limitaris Hall, 1860, p. 85. — Hall, 1867, p. 356, pl. 56, fig. 6-21.

Liorhynchus limitaris Hall and Clarke, 1893, p. 194, pl. 59, fig. 12, 35.

Leiorhynchus limitare Schuchert, 1897, p. 237.

Leiorhynchus limitaris Grabau and Shimer, 1909, p. 289, fig. 357, a-b.

Liorhynchus limitare Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 175, pl. 15, fig. 6-8.

Leiorhynchus limitare Cooper, in Shimer and Shrock, 1944, p. 313, pl. 119, fig. 42.

Shell small, suborbicular in outline, depressed biconvex in profile; greatest width about mid-length in position; surface plicate; length/width ratios for 9 specimens average 0.82.

Pedicle valve nearly flat; sulcus shallow, poorly defined in most specimens.

Brachial valve nearly flat; medial fold scarcely if at all elevated.

Surface plicate; plicae rounded, spaced about 5 per 2 mm near beak and 7 per 4 mm at margin, become obsolete laterally and near beak, increase by bifurcation; fine, uniformly spaced concentric striae on better preserved specimens.

Relationships.—Leiorhynchus limitare is represented in this collection by molds, chiefly internal molds of brachial valves. Pedicle and brachial

valves are difficult to determine with external molds inasmuch as folds and sulci cannot be differentiated, as a result of flattening. The original convexity of the shell is retained only in those specimens preserved as essentially unaltered hard parts in beds of limestone. This species is distinguished from other species of *Leiorhynchus* by its smaller size, and by its finer and more uniform plicae.

Leiorhynchus mesacostale (Hall)

Pl. 7, fig. 18-20

Atrypa mesacostalis Hall, 1843, fig. 1.
Leiorhynchus mesacostalis Hall, 1860, p. 86, fig. 1. — Hall, 1867, v. 4, p. 362, pl. 67, fig. 18-25.
Liorhynchus mesacostalis Hall and Clarke, 1893, v. 8, pt. 2, p. 194, pl. 59, fig. 11, 12.
Leiorhynchus mesacostale Schuchert, 1897, p. 238. — Cooper, in Shimer and Shrock, 1944, p. 313, pl. 119, fig. 4.

Shell medium in size, elongate-ovate in outline, biconvex; greatest width three-fourths distance forward of beak; surface plicate and sulcate.

Pedicle valve moderately convex; greatest convexity less than one-third distance forward of beak; length/width ratios for 4 specimens average 1.10; greatest width at or anterior to mid-length of valve; beak small, pointed, extends slightly behind hinge; sulcus about 0.4 valve width, with 4 or 5 broad plicae.

Brachial valve moderately convex; greatest convexity less than one-half distance forward of beak; beak scarcely developed; fold about 0.4 of valve width, with 4 or 5 plicae.

Plicae well developed on fold and sulcus, but indistinct on lateral slopes; faint, somewhat uneven concentric lamellae.

Interior brachial valve with strong median septum, the end of which functions for diductor muscle attachment; septum extends nearly one-half length of valve.

Pedicle valve: length—18.0 to 21.0 mm; width—15.0 to 20.0 mm.

Relationships.—This species is distinguished from other similar species by its larger size, well developed median septum, and by its surface ornament—the radial plicae are well developed only on the fold and sulcus, and are indistinctly developed on the lateral slopes.

Specimens of *L. mesacostale* in this collection are badly deformed, and precise measurements are, therefore, difficult to make. Some factor concerning the strength of shells of *Leiorhynchus* must be operative, for shells of this genus apparently are singled out for deformation—shells of *Ambocoelia umbonata*, *Emmanuella subumbona*, and others from the

same horizon as *Leiorhynchus mesacostale* are not deformed. Shells of this genus may be naturally thin.

Leiorhynchus multicostum Hall

Pl. 7, fig. 21

Leiorhynchus multicosta Hall, 1860, p. 85, fig. 14, 15 on p. 94. — Hall, 1867, p. 358, pl. 56, fig. 26-40.

Liorhynchus multicosta Hall and Clarke, 1893, pl. 59, fig. 8-10.

Liorhynchus laura Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 177, pl. 15, fig. 8-12.

Leiorhynchus multicostum Cooper, in Shimer and Shrock, 1944, p. 313, pl. 119, fig. 8, 9.

Shell medium-sized, subcircular to subovate in outline, biconvex, plicate; greatest width three-fourths distance forward of beak; anterior margin sulcate.

Pedicle valve depressed convex; greatest convexity equals 0.17 of greatest length; length/width ratio for one specimen 1.03; beak extends slightly behind hinge; cardinal slopes form right angle at beak, straight, pass imperceptibly onto broadly curving lateral margins; broad sulcus well defined, not raised much above lateral slopes, width at anterior margin about one-half greatest valve width.

Brachial valve depressed convex; greatest convexity equals 0.15 of greatest length; length/width ratio for one specimen is 1.0; fold well defined.

Surface bears 15 to 17 subequal, rounded costae; costae broader than furrows, number 1 per 2 mm at middle of anterior margin, increase by bifurcation, 4 or 5 in fold and sulcus.

Interior brachial valve bears median septum extending one-fourth valve length forward of beak and branching posteriorly to support socket plates and crura.

Pedicle valve: length—17.5 mm; width—17.0 mm; convexity—3.0 mm.

Relationships.—Leiorhynchus multicostum may be recognized by its medium size and biconvex profile. *Leiorhynchus limitare,* on the other hand, is considerably smaller and less biconvex. The costae are better defined in *L. multicostum* than in either *L. laura* or *L. mesacostale*, and these three species are nearly the same size.

Measurements of proportion and convexity of these specimens may be misleading, inasmuch as all of the specimens have been distorted. Other species within the same horizon, such as *Ambocoelia umbonata* and *Devonochonetes scitulus* are less deformed, perhaps owing to their thicker and stronger shells. Obtaining complete valves of this species

satisfactory for measurement is difficult. Consequently, the number of measured specimens is not an indication of the number of partial specimens used in identification of the species.

Genus Camarotoechia Hall and Clarke

Camarotoechia congregata (Conrad)

Pl. 7, fig. 22-28

Atrypa congregate Conrad, 1841, p. 55.

Rhynchonella (Stenocisma) congregata Hall, 1867, p. 341, pl. 54, fig. 44-59.

Camarotoechia congregata Hall and Clarke, 1893, p. 192, pl. 57, fig. 15-27. — Schuchert, 1897, p. 165. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 171, pl. 14, fig. 15-17. — Cooper, in Shimer and Shrock, 1944, p. 311, pl. 118, fig. 50-53.

Shell small to medium in size, shortened-ovate in outline, biconvex, plicate; greatest width at or anterior to middle of shell; length/width ratios average 0.89.

Surface of valve bears from at least 13 to 23 subangular plicae; plicae on brachial valve curve slightly toward posterior, rarely increase in number toward margins, number 3 to 4 on sulcus, number 5 to 6 on fold; concentric lamellae poorly shown on specimens in this collection, apparently spaced about 1 mm apart; later lamellae overlap earlier lamellae.

Interior of pedicle valve with divergent teeth; dental lamellae thin and subparallel, internally plicate outside of muscle areas.

Interior of brachial valve with divergent crura, faintly crenulated dental sockets, and very small cavity or incipient spondylium developed on posterior end of narrow median septum; median septum extends nearly to middle of valve.

Pedicle valve: length—9.0 to 14.0 mm; width—8.0 to 17.5 mm; convexity—1.5 to 5.0 mm.

Relationships.—This species may consist of two varieties in this collection, one of which generally is smaller, has a proportionately longer pedicle valve, has a greater number of plicae, and commonly has 4 rather than 3 plicae in the sulcus. These criteria, coupled with the stratigraphic separation, suggest that the two phenotypes represent varieties.

Camarotoechia congregata is distinguished from *C. prolifica* by its larger size and less numerous plicae. The apical half of larger specimens closely resembles *C. prolifica;* possibly *C. prolifica* is only the immature form of *C. congregata.* Hall (1867, p. 341), however, states that young

specimens of this species have about half as many plications as adult specimens; this would seem to preclude the possibility that *C. prolifica* represents *C. congregata* in its immature form. *Camarotoechia sappho* generallly has a greater number of plications than *C. congregata,* as well as more plications on the fold and sulcus.

Camarotoechia prolifica (Hall)

Pl. 7, fig. 29, 30

Rhynchonella (Stenocisma) prolifica Hall, p. 343, pl. 54A, fig. 1-10.
Camarotoechia prolifica Hall and Clarke, 1893, p. 192, pl. 57, fig. 42, 43. —Schuchert, 1897, p. 168. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 173, pl. 15, fig. 1-3.

Shell small, subtrigonal or shortened-ovate in outline, biconvex; greatest width at or anterior to middle of shell; lateral margins regularly rounded; anterior margin subtruncate; surface of shell plicate.

Surface bears 18 to 20 plicae; plicae uniformly spaced, subangular, apparent almost to beak, curve only slightly toward lateral margins; concentric striae scarcely discernible.

Interior pedicle valve with dental lamellae; lamellae very thin, extend about 0.20 distance forward of beak; internally plicate.

Interior brachial valve with divergent crura; median septum well defined, thin, extends one-third to one-half length of valve; anterolateral half of valve internally plicate.

Pedicle valve: length—7.0 to 9.0 mm; width—6.5 to 9.5 mm; convexity—1.5 mm.

Relationships.—Camarotoechia prolifica is distinguished from *C. sappho* and *C. congregata* by its smaller size and finer radial ornament. Further study may indicate that specimens referred to this species in this collection may represent immature forms of *C. congregata,* inasmuch as they commonly occur with specimens of *C. congregata.*

Camarotoechia sappho (Hall)

Pl. 7, fig. 31-33

Rhynchonella sappho Hall, 1860, p. 87.
Rynchonella (Stenocisma) sappho Hall, 1867, p. 340, pl. 54, fig. 33-43.
Camarotoechia sappho Hall and Clarke, 1893, p. 192, pl. 57, fig. 10-14. — Schuchert, 1897, p. 168. — Grabau and Shimer, 1909, p. 288, fig. 354, c, d. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 174, pl. 15, fig. 4. — Cooper, in Shimer and Shrock, 1944, p. 311, pl. 118, fig. 57-61.

Shell small to medium in size, subtrigonal in outline, biconvex; greatest width at or anterior to middle of shell; length/width ratios range from 0.70 to 0.85; surface plicate.

Surface bears 15 to 21 angular plications; plications broader than intervening furrows, slightly directed laterally, number 5 or 6 on fold.

Interior pedicle valve with divergent cardinal teeth; dental lamellae support teeth, thin, concave inward toward delthyrial cavity; internally plicate.

Internal brachial valve with divergent crura; median septum thin, extends about one-fourth length of valve, terminates posteriorly with small, triangular, incipient spondylium.

Pedicle valve: length—11.0 mm; width—13.5 mm; convexity—2.5 mm.

Relationships.—Specimens representing *C. sappho* in this collection are, for the most part, distorted, making measuring difficult. This species is distinguished from other species of *Camarotoechia* in the Mahantango Formation by its larger size, more prominently recurving plications, and more numerous plications on the fold.

Genus Hypothyridina Buckman

Hypothyridina venustula (Hall)

Pl. 7, fig. 34-37

Atrypa cuboides Vanuxem (not Sowerby), 1842, p. 163, fig. 1. — Hall, 1843, p. 215, fig. 1.

Rhynchonella venustula Hall, 1876, v. 4, p. 346, pl. 54A, fig. 24-43. — Williams, 1890, v. 1, p. 493, pl. 13, fig. 4, 8, 14, 23, 24, 27, 29, 31-34.

Hypothyris venustula Hall and Clarke, 1893, v. 8, pt. 2, pl. 60, fig. 49-55.

Hypothyridina venustula Cooper, in Shimer and Shrock, 1944, p. 315, pl. 120, fig. 5-7.

Shell medium-sized, subelliptical in outline, dorsi-biconvex; greatest width near middle of shell; surface costate; commissure strongly sulcate.

Pedicle valve moderately convex; greatest convexity one-third distance forward of posterior margin; length/width ratio 0.84 for one specimen; sulcus board, flat, nearly one-half of greatest valve width at anterior margin, forms deep U-shaped depression in anterior line of commissure.

Brachial very gibbous; height nearly equals length of valve; viewed anteriorly, valve profile is hemispherical; fold broad, raised above lateral slopes only in anterior half of valve.

Surface bears 42 to 48 costae rounded, increase by bifurcation, 18 to 20 on each lateral slope, 6 to 8 on fold and sulcus; all costae bifurcate at same proportional distance from beak, giving ornament a very regularly appearance; concentric growth varices faint, but developed especially toward margins.

Pedicle valve: length—18.0 mm; width—21.5 mm; convexity—4.0 mm.

Relationships.—Hypothyridina venustula is distinctive in its subelliptical outline, cuboidal profile, regularly costate ornament, and prominent sulcation.

Order STROPHOMENIDA

Superfamily STROPHOMENACEA

Family STROPHOMENIDAE

Genus LEPTAENA Dalman

LEPTAENA "RHOMBOIDALIS"

Pl. 7, fig. 38

Brachial valve concave, sharply geniculate toward anterior margin; subquadrate in outline with somewhat auriculate hinge line; surface with fine, radiating costellae and coarse concentric rugae.

Relationships.—Leptaena "rhomboidalis" is represented in this collection by an incomplete internal and external mold of a brachial valve; the features of this species, however, are so distinctive that no doubt exists as to the identification of the specimen. The specimen is riddled with borings, presumably of sponges.

Genus SCHUCHERTELLA Girty

SCHUCHERTELLA VARIABILIS Prosser and Kindle

Pl. 8, fig. 1-4

Schuchertella variabilis Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 144, pl. 11, fig. 6-10.

Shell small, subsemielliptical in outline, plano-convex; greatest width commonly at hinge; surface costellate.

Pedicle valve nearly flat to depressed convex; length/width ratios for 5 specimens average 0.69.

Brachial valve nearly flat to slightly convex; length/width ratios for 2 specimens average 0.72.

Surface bears numerous, strong costellae; costellae number 3 to 6 per 1 mm at anterior margin, increase toward anterior margin two-fold by intercalation; concentric striae fine, crowded, especially conspicuous in furrows between costellae.

Pedicle valve: length—5.0 to 8.0 mm; width—8.0 to 11.0 mm; convexity—0.5 mm.

Relationships.—Prosser and Kindle (1913, p. 145) consider the similarities and dissimilarities between this species and *Schuchertella per-*

versa ("Orthotetes (Streptorhynchus) perversus") and quote Dr. Clarke as saying that the two are probably conspecific. Specimens in this collection, however, are much closer in size and ornament to *"Streptorhynchus chemungensis* var. *arctostriata"* than to *"S. chemungensis* var. *perversa"* as described and illustrated by Hall (1867, p. 71-73, pl. 9, fig. 1-17). The regularly intercalating, sharp, narrow, somewhat sinuous costellae with crowded and fine concentric striae are distinguishing characteristics for this species. Some specimens exhibit the rather distorted beak typical for the genus *Streptorhynchus* Hall.

Family STROPHEODONTIDAE

Subfamily STROPHEODONTINAE

Genus STROPHEODONTA Hall

STROPHEODONTA DEMISSA (Conrad)?

Pl. 8, fig. 5

Strophomena demissa Conrad, 1842, p. 258, pl. 14, fig. 14. — Rogers, 1858, p. 827, fig. 666.
Strophomena (Strophodonta) demissa Hall, 1857, p. 137, fig. 1.
Strophodonta demissa Hall, 1867, p. 81, pl. 11, fig. 1-5.
Stropheodonta demissa Hall and Clarke, 1892, pl. 14, fig. 7-12. — Schuchert, 1897, p. 421. — Grabau and Shimer, 1909, p. 217, fig. 263. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 136, pl. 10, fig. 1. — Cooper, in Shimer and Shrock, 1944, p. 339, pl. 131, fig. 12-14.

Pedicle valve convex, approximately 15 mm long and 16 mm wide as measured on single specimen; greatest width at hinge.

Surface bears numerous costellae; costellae increase by intercalation to 8 per 1 mm at anterior margin, especially prominent in beak area.

Relationships.—One fragmental specimen is assigned questionably to this species on the basis of general outline, profile, and external ornament.

Genus MEGASTROPHIA Caster

MEGASTROPHIA (MEGASTROPHIA) CONCAVA (Hall)

Pl. 8, fig. 6

Strophomena (Strophodonta) concava Hall, 1857, p. 115, 140, fig. 1.
Strophodonta concava Hall, 1867, p. 96, pl. 16, fig. 1a-1h.
Stropheodonta concava Hall and Clarke, 1892, pl. 14, fig. 16-23. — Schuchert, 1897, p. 420. — Grabau and Shimer, 1909, p. 216, fig. 261.

— Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 139, pl. 10, fig. 6, 7.

Megastrophia concava Cooper, in Shimer and Shrock, 1944, p. 339, pl. 130, fig. 25; pl. 131, fig. 1-4.

Megastrophia (Megastrophia) concava Williams, 1953, p. 39, pl. 8, fig. 13-17.

Brachial valve large, concave; greatest concavity near middle of valve; medial furrow extends from anterior margin to posterior third of valve.

Surface parvicostellate; costellae low, about 1 per 1 mm near margins, separated by broad furrows with 3 to 6 secondary costellae between primary costellae; concentric striae fine, closely spaced; several concentric undulations are widely spaced.

Single measured specimen is at least 42 mm long, at least 60 mm wide, and 15 mm thick.

Relationships.—Megastrophia concava is represented in this collection by two incomplete external molds. This species is distinguished by its large size, and characteristic parvicostellate ornament.

Genus Protoleptostrophia Caster

Protoleptostrophia perplana (Conrad)

Pl. 8, fig. 7-15

Strophomena perplana Conrad, 1842, p. 257, pl. 14, fig. 11. — Rogers, 1858, p. 827, fig. 665.

Strophodonta perplana Hall, 1867, p. 92, 98, pl. 11, fig. 22.

Stropheodonta (Leptostrophia) perplana Hall and Clarke, 1892, p. 288, pl. 15, fig. 2-13. — Grabau and Shimer, 1909, p. 217, fig. 264. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 134, pl. 9, fig. 11-17.

Protoleptostrophia perplana Cooper, in Shimer and Shrock, 1944, p. 341, pl. 131, fig. 15-17.

Shell small to large, subquadrate in outline, plano-convex, costellate; greatest width at hinge; cardinal extremities form right angles, mucronate on some specimens.

Pedicle valve nearly flat; length/width ratios for 7 specimens average 0.86; small forms relatively more transverse than large forms.

Brachial valve nearly flat to slightly concave.

Surface bears 100 to 300 costellae; costellae subequal, rounded, narrower than intervening furrows, number 4 per 1 mm at middle of anterior margin, increase by intercalation; concentric rugae widely spaced; some specimens with medial cicatrix.

Interior pedicle valve with denticulate hinge line; median septum weak, extends less than half valve length; muscle scars well defined; shell pseudopunctate, especially posterior half and postero-lateral elevations bounding muscle areas.

Interior brachial valve with denticulate hinge line; cardinal process very prominent, disjunct bilobed with lobes postero-dorsally or dorsally directed; base of cardinal process continues anteriorly as three linear elevations.

Pedicle valve: length—9 to 28 mm; width—12 to 28 mm; convexity—1 to 2 mm.

Relationships.—Protoleptostrophia Caster (1939) amended by Williams (1953) is distinguished from *Leptostrophia* by its disjunct bilobed cardinal process, its absence of socket plates, and its smaller size. This species is characterized by its nearly flat profile, somewhat mucronate cardinal extremities, and the numerous, subequal costellae. Hall (1867, p. 99, pl. 17, fig. 1f, 1o) has noted that specimens of this species taken from Illinois and Iowa possess fasciculate costellae. About ten percent of the specimens in this collection exhibit a cicatrix; the presence of such a feature has been interpreted by Hall (1867, p. 99) as being the result of injury to the individual. It appears as though this feature is confined to the brachial valve and is especially common among specimens from the upper part of the Mahantango Formation. Only a few specimens show the fine concentric striae and spinose development along the costellae that are described by Hall.

Subfamily Strophonellinae

Genus Pholidostrophia Hall and Clarke

Pholidostrophia (Pholidostrophia) pennsylvanica Kindle

Pl. 8, fig. 16, 17

Pholidostrophia pennsylvanica Kindle, 1912, p. 74, pl. 5, fig. 1, 2. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 141, pl. 10, fig. 8, 9.

Shell small, subquadrate to subsemicircular in outline, concavo-convex; greatest width at hinge; cardinal angles salient; length/width ratios average 0.70.

Pedicle valve depressed convex; length/width ratios average 0.66 for three specimens; hinge coarsely denticulate along half of its length on either side of beak.

Brachial valve concave, slightly geniculate.

Surface smooth, with nacreous luster; concentric lirae fine, especially evident near margins; concentrically undulose.

Pedicle valve: length—7.0 to 9.5 mm; width—11 to 16 mm; convexity—1 to 2 mm.

Relationships.—The specimens referred to *Pholidostrophia pennsylvanica* in this collection are intermediate in size between *P. iowaensis* (*Stropheodonta nacrea* Hall) and *P. pennsylvanica* Kindle. In addition to the lustrous exterior, so distinctive for this genus, these specimens have salient cardinal angles, a feature used by Kindle to differentiate *P. pennsylvanica* from *P. iowaensis*.

Subfamily Douvillininae

Genus Douvillina Oehlert

Douvillina inaequistriata (Conrad)

Pl. 8, fig. 18-21

Strophomena inaequistriata Conrad, 1842, p. 254, pl. 14, fig. 2.
Strophomena (Strophodonta) inaequistriata Hall, 1857, p. 142.
Strophodonta inaequistriata Hall, 1867, p. 93, pl. 12, fig. 6-8.
Stropheodonta (Douvillina) inaequistriata Hall and Clarke, 1892, p. 289, pl. 14, fig. 1-6; pl. 15B, fig. 9.
Stropheodonta inaequistriata Schuchert, 1897, p. 422. — Grabau and Shimer, 1909, p. 217, fig. 262. — Kindle, 1912, p. 76, pl. 3, fig. 2-4.
Stropheodonta (Douvillina) inaequistriata Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 138, pl. 10, fig. 2-5.
Douvillina inaequistriata Cooper, in Shimer and Shrock, 1944, p. 341, pl. 132, fig. 8-11.

Shell medium-sized, subsemielliptical in outline, concavo-convex; greatest width at hinge; length/width ratios average 0.70.

Pedicle valve depressed convex to moderately convex; length/width ratios range from 0.64 to 0.74 for four specimens.

Brachial valve concave; concavity not equal to convexity of pedicle valve.

Surface unequally parvicostellate; primary costellae number about 3 per 1 mm near margin; 1 to 4 secondary costellae between primary costellae; costellae increase by intercalation; concentric lamellae few, confined to anterior fourth of shell.

Interior pedicle valve with denticulate hinge line; muscle scars flabellate, occupy area one-third of valve length and one-third of valve width; posterior tips of diductor scars form 2 small, closely spaced notches in interarea; adductor scars small, subcircular, just anterior to hinge; diductor scars bounded laterally by 2 prominent, inwardly concave, subparallel ridges, separated medially by short septum; septum terminates

anteriorly with small boss; surface pustulose except for muscle areas; pustules coarse in postero-central third of valve; striae evident near margins.

Interior brachial valve not represented in this collection.

Pedicle valve: length—13.5 to 18.5 mm; width 18 to 29 mm; convexity—1.5 to 5.5 mm.

Relationships.—This species is distinguished primarily by its unique muscle areas bounded laterally by short, subparallel ridges and terminating posteriorly with 2 small notches in the interarea. In many respects, it resembles *Stropheodonta textilis,* but that species, generally, is much larger. The specimens of *D. inaequistriata* in this collection conform in nearly all respects to *D.* aff. *inaequistriata* illustrated by Williams (1953, pl. 11, fig. 10), except for the somewhat less transverse outline of specimens in this collection.

Douvillina inaequistriata var. immatura Ellison, n. var.

Pl. 8, fig. 22-27

Shell small, transversely subelliptical in outline, concavo-convex; anterior and lateral margins regularly rounded; greatest width at middle of shell; length/width ratios average 0.69 for three specimens.

Pedicle valve depressed convex; greatest convexity near middle of valve, equals less than 0.20 of valve length; interarea low, obtuse.

Brachial valve nearly flat to slightly concave; greatest concavity anterior to middle of valve, equals less than 0.10 of valve length.

Surface parvicostellate; primary costellae number 5 per 2 mm at anterior margin; secondary costellae number 2 to 5 between primary costellae, increase by intercalation.

Interior pedicle valve with denticulate hinge line; denticulation extends two-thirds of hinge length on either side of beak, with teeth inclined so as to be nearly parallel with margins of delthyrium; two muscle-bounding ridges border diductor muscle areas, diverge from beak at angle of about 70°, thin, extend one-third length of valve; two inner muscle-bounding ridges somewhat shorter than outer ridges, subparallel; median septum thin, somewhat shorter than inner muscle-bounding ridges; entire inner surface is pseudopunctate.

Interior brachial valve with transverse depression just anterior to middle of hinge; depression divided by short median septum, bounded laterally by short, laterally convex socket plates; median septum bifurcates anteriorly into two strong, slightly divergent, tuberculate brace-plates; muscle-bounding ridges represent anterior extension of socket

plates, separated from braceplates by thin cleft; inner surface costellate, reflecting external ornament.

Measurements of specimens are given in table 7.

Relationships.—Douvillina inaequistriata var. *immatura* is recognized by its small size, flattened concavo-convex profile, and internal features of both the pedicle and brachial valves. Thin, divergent muscle-bounding ridges on the pedicle valve, and strong braceplates and muscle-bounding ridges on the brachial valve are distinctive features of this variety. The brachial interior of this variety is nearly identical with the brachial interior of *Douvillina (Douvillina)* aff. *inaequistriata* illustrated by Williams (1953, pl. 11, fig. 12), and collected from the West Brook Member of the Tully Formation at Sherburne, New York.

Some uncertainty remains concerning the separation of *D. inaequistriata* from *D. inaequistriata* var. *immatura*. Except for the nature of the pedicle muscle area and the size of the shell, these two forms are nearly identical. The difference in size loses emphasis, however, if one considers length/width proportions and the change in proportion with growth. Such proportions and changes in proportion are similar for *D. inaequistriata* and *D. inaequistriata* var. *immatura*. The differences in muscle areas are more difficult to explain, but changes in muscle areas could very well accompany growth. The lack of transitional forms may support the view that these are two varieties rather than mature and immature specimens of the same species.

Superfamily CHONETACEA

Genus CHONETES Fischer

"CHONETES" cf. C. LEPIDUS (Hall)

Pl. 9, fig. 10

Chonetes lepida Hall, 1857, p. 148. — Hall, 1867, p. 142, pl. 22, fig. 12, 13.

Chonetes lepidus Schuchert, 1897, p. 175. — Grabau and Shimer, 1909, v. 1, p. 237, fig. 289, d, e. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 153, pl. 12, fig. 9-13.

Pedicle valve very small to small, subsemicircular to subelliptical in outline, moderately convex; length/width ratios average 0.68 for 7 specimens; sulcus deepest at position of greatest convexity, becoming shallower and 0.25 greatest width at anterior margin; at least 3 somewhat obliquely directed cardinal spines on either side of beak.

Surface bears 12 to 20 subequal, rounded plicae; 3 to 4 plicae per 1 mm at middle of anterior margin; increase by implantation; sulcus bounded by 2 stronger plicae; 1 or 2 implanted plicae on sulcus.

TABLE 7. *Measurements of new brachiopod species from the Mahantango Formation of south-central Pennsylvania.*

Explanation of abbreviations:

L — length, in mm
W — width, in mm
HW — hinge, width, in mm
C — convexity, in mm
PGW — position of greatest width, in mm forward of beak
PGC — position of greatest convexity, in mm forward of beak
Bk — beak behind hinge, in mm
S-F — width of sulcus or fold, in mm
R — number of ribs
$\frac{R}{mm}$ — number of ribs per 1 mm
$\frac{R}{S\text{-}F}$ — number of ribs on sulcus or fold
$\frac{L}{W}$ — length/width ratio
$\frac{C}{L}$ — convexity/length ratio
$\frac{PGW}{L}$ — position of greatest width/length ratio
$\frac{PGC}{L}$ — position of greatest convexity/length ratio
Sp — number of cardinal spines

Species	*Valve*	*L*	*W*	*HW*	*C*	*PGW*	*PGC*	*Bk*	*S-F*	*R*	$\frac{R}{mm}$	$\frac{R}{S\text{-}F}$	$\frac{L}{W}$	$\frac{C}{L}$	$\frac{PGW}{L}$	$\frac{PGC}{L}$	*Sp*
Douvillina	Pedicle	6.5	8.5	8.0	0.5	....	....	....	....	....	....	....	0.77	0.08	....	....	....
inaequistriata	Do.	8.5	12.0	12.0	2.0	....	....	....	....	....	....	....	0.71	0.24	....	....	....
var. immatura	Brachial	7.0	11.0	10.0	0.5	....	....	....	....	....	....	....	0.64	0.07	....	....	....
Spinocyrtia	Pedicle	32.5	42	42	10.0	....	14.0	11.0	16.0	16	....	....	0.78	0.31	....	0.43	....
granulosa	Do.	....	49	49	11.0	....	....	....	13.0	....	....	....	....	....	....	....	....
girtyi	Brachial	19.0	40	40	7.0	....	9.0	1.5	8.0	16	0.7	....	0.48	0.37	....	0.47	....
Mediospirifer	Pedicle	14.0	29.0	29.0	5.0	....	3.0	....	5.0	19	....	....	0.48	0.36	....	0.21	....
audaculus	Do.	14.0	30.0	30.0	6.5	....	2.0	2.0	5.5	16	0.8	....	0.47	0.46	....	0.14	....
	Do.	18.0	38.0	38.0	7.0	....	4.0	5.0	7.0	23	0.9	....	0.47	0.39	....	0.22	....
	Do.	19.0	31.0	31.0	6.0	....	5.0	5.0	6.5	15	0.8	....	0.63	0.32	....	0.26	....
	Do.	19.0	38.0	38.0	5.0	....	5.0	2.5	8.5	21	1.0	....	0.50	0.26	....	0.26	....
	Do.	23.5	50.0	50.0	8.0	....	6.0	5.0	9.0	19	0.7	....	0.47	0.34	....	0.26	....
	Do.	25.0	41.5	41.5	9.0	....	10.5	4.5	11.0	18	0.8	....	0.60	0.30	....	0.42	....
	Do.	33.0	47.0	47.0	10.0	....	8.0	7.0	12.0	17	0.5	....	0.70	0.30	....	0.24	....
	Brachial	10.0	22.0	22.0	1.5	....	5.0	....	3.0	16	1.1	....	0.46	0.15	....	0.50	....
	Do.	17.0	32.0	32.0	6.0	....	9.0	....	8.5	20	0.8	....	0.53	0.35	....	0.53	....
	Do.	22.5	42.0	42.0	8.5	....	8.0	....	12.0	18	0.8	....	0.54	0.38	....	0.36	....
	Do.	25.0	54.0	54.0	9.0	....	13.0	2.0	14.0	17	0.5	....	0.46	0.36	....	0.52	....
Mediospirifer	Pedicle	15	27	27	5.5	....	3.5	3.0	3.0	11	0.8	....	0.56	0.37	....	0.23	....
bellitropis	Do.	21	28	28	6.0	....	4.0	4.5	7.5	....	....	....	0.75	0.29	....	0.19	....
	Do.	30	40	40	15.0	....	12.0	7.0	12.0	16	....	....	0.75	0.50	....	0.40	....
	Brachial	17	25	25	6.5	....	6.0	1.5	6.5	12	....	....	0.68	0.38	....	0.35	....
	Do.	18	30	30	4.5	....	6.0	2.0	9.0	13	0.8	....	0.60	0.25	....	0.33	....
	Do.	23	32	32	11.5	....	10.0	2.5	11.5	13	0.8	....	0.72	0.50	....	0.43	....

Mediospirifer dromgoldi	Pedicle	10	13	12	6.0	5.0	3.0	....	4.0	....	....	....	0.56	0.60	....	....	....
	Do.	15	16	....	7.5	....	5.0	....	6.5	8	....	....	0.94	0.50	....	....	....
	Do.	16	17	17	6.0	....	5.0	....	5.5	7	....	....	0.94	0.38	....	....	....
	Do.	16	19	15	6.0	5.5	5.0	....	6.5	....	....	....	0.84	0.38	....	....	....
	Do.	16	20	....	6.0	....	....	....	6.5	8	....	....	0.80	0.38	....	....	....
	Do.	18	.	....	7.5	....	5.0	....	.	....	....	....	....	0.42	....	....	....
	Do.	19	18	....	8.0	....	7.0	....	8.0	....	....	....	1.05	0.42	....	....	....
	Do.	20	....	....	8.5	....	8.0	....	....	....	....	....	....	0.43	....	..	.
	Do.	23	28	28	8.0	....	9.0	....	8.5	....	....	....	0.82	0.34	....	.	
	Brachial	14.0	20	20	5.0	....	6.5	....	4.5	9	....	....	0.70	0.36	. .	0.47	
	Do.	14.0	....	....	6.5	....	7.0	....	5.0	8	....	....	....	0.46	....	0.50	....
	Do.	16.5	23	23	6.5	....	9.0	....	8.0	9	....	....	0.72	0.39	. .	0.55	....
	Do.	17.0	23	23	7.0	....	8.5	....	7.0	8	....	...	0.74	0.41		0.50	. .
	Do.	20.0	30	30	8.0	....	8.0	....	8.0	8	....	...	0.67	0.40	....	0.40	....
Mediospirifer belliplicata	Pedicle	11.5	16	16	5.0	....	3.5	2.5	3.5	9	1.2	....	0.72	0.43	.	0.30	....
	Do.	20.0	30	30	7.0	....	6.5	4.0	8.5	12	0.6	.	0.67	0.35	....	0.32	. .
	Do.	20.5	25	25	7.0	. .	8.0	5.0	6.5	9	0.7	..	0.82	0.34	.	0.39	....
Mediospirifer millerstownensis	Pedicle	21	32	28	8	8.0	6	....	10.5	11	....	.	0.66	0.38	0.38	0.29	....
	Do.	22	26	25	**7**	10.5	7	....	9.0	10	....	....	0.85	0.32	0.48	0.31	....
	Do.	23	31	27	10	10.0	9	....	10.0	15	....		0.74	0.45	0.44	0.39	....
	Do.	24	32	30	9	11.0	8	.	9.0	....	....	..	0.75	0.38	0.46	0.33	....
	Do.	26	31	28	10	11.0	9		10.0	13	....		0.84	0.38	0.42	0.35	....
	Do.	26	31	28	10	12.0	9		8.0	9	....	....	0.84	0.38	0.46	0.34	....
	Do.	26	34		10	13.0	7		8.5	.	....	....	0.77	0.38	0.50	0.27	....
	Do.	28	35	33	10	13.0	8	....	**8.0**	10	....	....	0.80	0.36	0.46	0.29	....
	Brachial	15.0	23	20	3.5	5.5	6.5	.	5.0	13	....		0.65	....	....	. .	....
	Do.	22.0	35	31	7.5	7.0	12.0		9.0	12	...		0.63	....	....	....	....
	Do.	22.5	36	32	9.0	8.0	11.0	.	8.5	13	....	.	0.63	....	....	....	....

Pedicle valve: length—1.3 to 3.4 mm; width—1.8 to 5.1 mm; convexity—1.0 mm.

Relationships.—As represented in the collection at the U. S. National Museum, *"Chonetes" lepidus* is distinguished from *Devonochonetes scitulus* by the more nearly quadrate outline of its pedicle valve as well as its greater convexity, by its smaller size, and by its more elevated and distinct costellae. Applying these criteria to specimens of *"Chonetes"* in the collection under consideration, however, produces no clear-cut separation. For this reason, only those small specimens which exhibit the pedicle sulcus bounded by two somewhat more prominent costellae have been assigned to *"Chonetes"* cf. *C. lepidus.* Even such a distinction is open to considerable question, inasmuch as the smaller specimens collected by Beecher to represent the early phases in the ontogeny of *Devonochonetes scitulus* in the U. S. National Museum, are nearly identical with *"C." lepidus* as defined by Hall and as used in this study. Kindle and Prosser's suggestion (1913, p. 154), following Nicholson (1874, p. 74), that *"C." lepidus* is merely the immature form of *Devonochonetes scitulus,* may be correct, particularly insofar as the two commonly occur together.

Genus Devonochonetes Muir-Wood

Devonochonetes coronatus (Conrad)

Pl. 9, fig. 2-9

Strophomena carinata Conrad, 1842, p. 257, pl. 14, fig. 13.

Chonetes coronata Hall, 1857, p. 146, fig. 1, 2. — Hall, 1867, p. 133, pl. 21, fig. 9-12. — Hall and Clarke, 1892, pl. 16, fig. 10, 11, 24, 26, 33, 39, 41, 43.

Chonetes coronatus Schuchert, 1897, p. 173. — Grabau and Shimer, 1909, p. 236, fig. 288. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 148, pl. 11, fig. 18-21. — Cooper, in Shimer and Shrock, 1944, p. 345, pl. 134, fig. 12-15.

Devonochonetes coronatus Muir-Wood, 1962, p. 43, pl. 10, fig. 1a-c, 2.

Shell medium to large, subquadrate to subelliptical in outline, planoconvex to concavo-convex, costellate; greatest width at or anterior to hinge; cardinal extremities rectangular to slightly acuminate.

Pedicle valve moderately convex; maximum convexity averages 0.26 of valve length for 2 specimens, situated 0.33 of valve length forward of beak; length/width ratios average 0.81.

Brachial valve flat to moderately concave; maximum concavity averages 0.23 of valve length at about 0.4 of valve length from posterior

margin; length/width ratios average 0.68; smaller forms somewhat more transverse in outline than large forms; some forms abruptly depressed immediately in front of hinge.

Surface bears 70 to 90 subangular costellae; increase by implantation; costellae bend slightly backward on some specimens.

Pedicle valve: length—20.5 to 24.0 mm; width—27.5 to 28.0 mm; convexity—5.0 to 6.5 mm.

Relationships.—Devonochonetes coronatus is characterized primarily by it large size and numerous costellae. Specimens in this collection exhibit considerable variability in characters such as outline, convexity and concavity and position of greatest width. None of these characters, however, bears a consistent relationship to size and therefore this variability cannot be ascribed to growth, at least as far as the present study has been able to ascertain. Hall (1867) indicates that this species commonly is wider in front of hinge than at the hinge. Kindle and Prosser (1913) generally agree and, in addition, illustrate specimens that show a definite sulcation of the pedicle valve. Specimens referred to this species in this collection are not sulcate and generally are widest at the hinge. It is a rather curious fact that cardinal spines are unknown in this collection of *D. coronatus*. Although Kindle and Prosser indicate that Maryland specimens possess cardinal spines, no illustration of specimens with more than stumps of spines is given.

Devonochonetes scitulus (Hall)

Pl. 9, fig. 13-34

Chonetes scitula Hall, 1857, p. 147. — Hall, 1867, p. 130, pl. 21, fig. 4. — Hall and Clarke, 1892, pl. 16, fig. 3, 4, 27, 32, 40, 44.

Chonetes scitulus Beecher, 1891, p. 357, pl. 17, fig. 14. — Schuchert, 1897, p. 178. — Grabau and Shimer, 1909, p. 237, fig. 289, a, b. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 150, pl. 12, fig. 1-8. — Cooper, in Shimer and Shrock, 1944, p. 345, pl. 134, fig. 11.

Devonochonetes scitulus Muir-Wood, 1962, p. 44.

Shell small, subquadrate to subelliptical in outline, plano-convex to concavo-convex; greatest width at middle of shell; no more than 5 nor less than 2 short spines along cardinal slope on either side of beak; surface costellate.

Pedicle valve moderately convex; medially flattened on some specimens; greatest convexity equals 0.29 of valve length; length/width ratios for 17 specimens average 0.76; larger specimens more transverse than

smaller specimens; hinge slightly less than greatest width; cardinal spines short, inclined to hinge, curve slightly upward, tapering, number 2 to 5 on either side of beak.

Brachial valve nearly flat to slightly concave; greatest concavity equals 0.16 of valve length; length/width ratios average 0.68 for 10 specimens.

Surface costellate; costellae number 3 or 4 per 1 mm at anterior margin, number 22 to 77 on specimens described, thinner than intervening furrows, increase by intercalation, tuberculate on larger specimens; concentric filae numerous, fine, anastomose.

Pedicle valve: length—2.5 to 9.0 mm; width—3.8 to 12.4 mm; convexity—1.0 to 3.0 mm.

Relationships.—Devonochonetes scitulus, in contrast with *D. coronatus*, always has the greatest width below the hinge, and is about half as large as that species. In addition, *D. scitulus* has fewer cardinal spines—4 to 12 vs. 10 to 14—than *D. coronatus*. The number of costellae and internal features of the valves of both species are similar. *Devonochonetes syrtalis* generally occurs with *D. scitulus*, and, except for the difference in size, these two species are very much alike. Further study may show that specimens of *D. syrtalis* are but larger forms of *D. scitulus*. *"Chonetes" lepidus*, on the other hand, is smaller than *D. scitulus*, and is nearly identical with young specimens of *D. scitulus*. Young specimens from ontogenetic series assembled by Beecher, and now in the U. S. National Museum are indistinguishable from specimens of *"Chonetes" lepidus*. The two species commonly are associated stratigraphically; therefore, they may be different size-representatives of one species. Compared with *Retichonetes marylandicus*, *Devonochonetes scitulus* is less convex, has fewer radial costellae, and lacks the fine, thread-like striae on the costellae, so typical of *Retichonetes marylandicus*.

Devonochonetes syrtalis (Conrad)

Pl. 9, fig. 35-40

Strophomena syrtalis Conrad 1842, p. 257, pl. 14, fig. 13.
Chonetes syrtalis Hall, 1867, pl. 21, fig. 13, a-c. — Cooper, in Shimer and Shrock, 1944, p. 345, pl. 134, fig. 21-23.
Devonochonetes syrtalis Muir-Wood, 1962, p. 44.

Shell medium to large in size, concavo-convex, subquadrate to subsemielliptical in outline, costellate; greatest width at hinge; cardinal extremities form right angles, somewhat auriculate.

Pedicle valve depressed convex; greatest convexity equals 0.19 of valve length; length/width ratios for 5 specimens average 0.63.

Brachial valve nearly flat; greatest concavity equals 0.05 of valve length; length/width ratios for 2 specimens average 0.62.

Surface bears about 100 costellae; costellae subequal, subangular, equal in strength and breadth to intervening furrows, number 2 to 3 per 1 mm at middle of anterior margin, increase by intercalation.

Pedicle valve: length—12.0 to 23.0 mm; width—19.0 to 33.0 mm; convexity—2.0 to 5.0 mm.

Relationships.—Devonochonetes syrtalis is similar in many respects to *D. coronatus*, but the latter commonly has a more convex pedicle valve and a more concave brachial valve than *D. syrtalis*. Although the costellae of this species are somewhat finer and more numerous than those of *D. coronatus*, the marked variability in number and nature of the costellae in both species detracts from the usefulness of these characteristics in distinguishing between these two species. However, this species does occur in horizons with *D. scitulus* in south-central Pennsylvania. Thus, it may be only a large size representative of that species.

Genus Longispina Cooper

Longispina mucronatus (Hall)

Pl. 10, fig. 1-8

Strophomena mucronata Hall, 1843, p. 180, fig. 3.
Chonetes laticosta Hall, 1857, p. 119.
Chonetes mucronata Hall, 1867, p. 123, pl. 20, fig. 1, a-d; pl. 21, fig. 1, a-g.
Chonetes mucronatus Schuchert, 1897, p. 176. — Grabau and Shimer, 1909, p. 235, fig. 286. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 146, pl. 11, fig. 11-17.
Longispina mucronatus Cooper, 1942, p. 230.

Shell small, concavo-convex, subquadrate to subelliptical in outline; greatest width anterior to hinge; anterior and lateral margins regularly to broadly rounded; 3 cardinal spines on either side of beak.

Pedicle valve moderately gibbous, relative convexity increasing with size; greatest convexity equals one-third of valve length; hinge width slightly less than greatest width; length/width ratios for 6 specimens average 0.75, and large valves are relatively longer than small valves; cardinal spines inclined from 20 to 40 degrees from the cardinal slope in their proximal portions, 5 to 15 degrees from the cardinal slope in their distal portions; outermost spines more nearly parallel to slope than innermost spines.

Brachial valve less concave than convexity of pedicle valve.

Surface costate; costae number 2 per 1 mm at middle of anterior margin, increase by bifurcation but only rarely, radiate from imaginary point beyond hinge, not straight, variable in strength; concentric striae number 2 to 4 near anterior margin, widely and nearly equally spaced.

Pedicle valve: length—4.2 to 8.7 mm; width—6.4 to 10.1 mm; convexity—1.0 to 4.6 mm.

Relationships.—Longispina mucronatus is distingiushed from all other chonetids in this collection in having cardinal spines which are parallel or subparallel to the hinge. Specimens of this species illustrated by Hall (1867) and Prosser and Kindle (1913) are notable in being strongly pustulose; however, specimens of *L. mucronatus* in the present collection generally lack pustules except on the cardinal extremities. *Longispina emmetensis* (Winchell), the genotype for *Longispina* has fewer costae than *L. mucronatus,* and the costae of that species do not appear to radiate from a point beyond the hinge.

Longispina mucronatus differs from *Retichonetes vicinus* in being smaller, having fewer and coarser costae, and, at least for specimens in this collection, in having spines subparallel to the hinge, a feature lacking in specimens of *R. vicinus.*

Genus Retichonetes Muir-Wood

Retichonetes? aurora (Hall)

Pl. 9, fig. 1

Chonetes logani var. *aurora* Hall, 1867, v. 4, p. 137, pl. 22, fig. 16-28.
Chonetes aurora Cooper and Williams, 1935, p. 838, pl. 57, fig. 2, 5, 6, 7, 9. — Shimer and Shrock, 1944, p. 345, pl. 134, fig. 10.
Retichonetes? aurora Muir-Wood, 1962, p. 64.

Shell very small, concavo-convex, subsemicircular in outline.

Surface with about 20 costae and numerous concentric rugae, giving surface reticulate appearance; costae increase by bifurcation and implantation.

Measurements: length of pedicle valve—2.5 mm; width—3 mm.

Relationships.—Retichonetes? aurora can be recognized by its small size and reticulate ornament. No other species of *"Chonetes"* in the Mahantango or Harrell Formations bears such well-defined concentric ornament. The two specimens of *R. aurora* in the present collection do not have the cardinal spines intact. Cooper and Williams (1935, p. 838) comment that in New York this species is as characteristic of the Apulia and Laurens Members of the Tully Formation as is *Hypothyridina venustula.*

Retichonetes marylandicus (Prosser and Kindle)

Pl. 9, fig. 11, 12; pl. 19, fig. 15

Chonetes marylandicus Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 157, pl. 13, fig. 1-6.
Retichonetes marylandicus Muir-Wood, 1962, p. 62.

Shell small, subsemielliptical to subsemicircular in outline, concavo-convex, costellate; greatest width one-third distance forward of posterior margin; cardinal slopes with at least two suberect spines.

Pedicle valve very convex; greatest convexity equals 0.35 length of valve; length/width ratios for 4 specimens average 0.75; small forms relatively more transverse than large forms.

Brachial valve concave; greatest concavity equals 0.30 length of valve; length/width ratios for 4 specimens average 0.71.

Surface bears 48 to 72 costellae; costellae subequal, subangular, narrower than intervening furrows, number 7 per 2 mm at anterior margin, increase by intercalation; fine, thread-like striae superimposed on costellae toward margins.

Pedicle valve: length—8.5 to 10 mm; width—11.0 to 13.5 mm; convexity—3.0 to 3.5 mm.

Relationships.—This species is found several places, including a relatively narrow stratigraphic zone at Everett along the turnpike. Kindle and Prosser (1913, p. 158) mention its similarity with *R. vicinus,* but it is readily distinguished from that species by its more numerous costellae as well as the thread-like striae that are superimposed on the costellae. These striae serve to differentiate *R. marylandicus* from all other similar "*Chonetes*" species. In this collection, it is difficult to differentiate *R. marylandicus* from *Devonochonetes scitulus,* partly as a result of the fact that the numerous cardinal spines distinctive for *D. scitulus,* and the thread-like striae that are distinctive for *R. marylandicus* are only infrequently observed. Specimens of *R. marylandicus* in the U. S. National Museum are larger and more strongly concavo-convex than *D. scitulus,* and have more numerous and finer radial costellae.

Retichonetes vicinus (Castelnau)

Pl. 9, fig. 41, 42

Leptaena vicina Castelnau, 1843, p. 39, pl. 14, fig. 9.
Chonetes deflecta Hall, 1857, p. 149. — Hall, 1867, p. 126, pl. 21, fig. 7, 8. — Hall and Clarke, 1892, pl. 16, fig. 28.
Chonetes vicinus Schuchert, 1897, p. 180. — Grabau and Shimer, 1909, p. 236, fig. 287. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 155, pl. 12, fig. 14-21.
Longispina vicinus Cooper, 1942, p. 230.
Retichonetes vicinus Muir-Wood, 1962, p. 62.

Shell medium size, semielliptical to semicircular in outline, concavo-convex, costate; greatest width at hinge; cardinal extremities nearly rectangular, acuminate in some specimens.

Pedicle valve very convex; greatest convexity equals nearly 0.4 of valve length; length/width ratios for one specimen 0.79; cardinal slopes resupinate, outer portions parallel to hinge; interarea low, very obtuse and longitudinally striate; delthyrium nearly three times as wide as high, open.

Brachial valve very concave; some forms very abruptly depressed just anterior to hinge; greatest concavity equals 0.34 of valve length; length/width ratios average 0.72.

Surface bears 19 to 36 strong, subangular costae which increase by implantation and bifurcation; costae number 6 to 8 per 5 mm at middle of anterior margin; concentric lamellae uncommon and widely spaced; three cardinal spines on either side of beak diverge at their bases and become suberect.

Pedicle valve: length—9.5 to 10.0 mm; width—12.0 mm; convexity—3.5 mm.

Relationships.—Kindle and Prosser (1913, p. 157) cite the strong convexity, semielliptical outline, deflected cardinal angles, and the numerous, fine, and closely crowded striae as features which serve to separate this species from *Longispina mucronatus*. However, in the present collection, distinction was made essentially on the basis of difference in size—*Retichonetes vicinus* being considerably larger than *L. mucronatus*—and the fact that the cardinal spines of *R. vicinus* do not parallel the hinge line as they do in *L. mucronatus*.

Superfamily Productacea

Genus Productella Hall

Productella spinulicosta (Hall)

Pl. 8, fig. 28-31

Productus spinulicostus Hall, 1857, p. 173.

Productella spinulicostus Hall, 1867, p. 160, 8, pl. 17, fig. 2-6. — Schuchert, 1897, p. 318. — Grabau and Shimer, 1909, p. 241, fig. 293, c, d.

Productella cf. *P. spinulicosta* Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 162, pl. 13, fig. 17.

Productella spinulicosta Cooper, in Shimer and Shrock, 1944, p. 347, pl. 135, fig. 29, 30.

Shell of medium size, concavo-convex, subcircular to subelliptical in outline; greatest width near middle of shell; margins regularly rounded; surface spinose.

Pedicle valve moderately to very convex; viewed anteriorly, valve is subangularly convex; length/width ratios for 6 specimens average 0.84; hinge line straight, averages about six-sevenths of greatest width.

Brachial valve concave; greatest concavity equals about one-fourth of valve length.

Surface spinose; spines numerous, radiating, form nearly continuous radiating spiniferous ridges on some specimens, moderately long, attain lengths of 6 mm on specimen 21 mm in length; concentric plications uncommon; cardinal slope with at least 3 slender spines on either side of beak.

Pedicle valve: length—12.0 to 19.0 mm; width—12.0 to 30.0 mm; convexity—4.0 to 7.0 mm.

Relationships.—The spinose character of the shell of *Productella spinulicosta* serves to distinguish this species from all others in the Hamilton Group of south-central Pennsylvania, except perhaps from *Truncalosia truncata*, but that species is much smaller. The spines range from little more than elongate pustules to nearly continuous radiating ribs lying flat on the surface of the shell.

Truncalosia truncata (Hall)

Pl. 8, fig. 32

Productus truncatus Hall, 1857, p. 171.
Productella truncata Hall, 1867, p. 160, pl. 23, fig. 12-24.
Strophalosia truncata Beecher, 1890, p. 24. — Hall and Clarke, 1892, p. 316, pl. 15B, fig. 24-26; pl. 17, fig. 10-15. — Grabau and Shimer, 1909, p. 240, fig. 292. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 160, pl. 13, fig. 14-16.
Productella truncata Cooper, in Shimer and Shrock, 1944, p. 347, pl. 135, fig. 21-23.
Truncalosia truncata Imbrie, 1959, p. 401.

Brachial valve small, flat, semielliptical in outline; lateral margins regularly rounded, truncated posteriorly by straight hinge; hinge width slightly less than greatest width of valve; greatest width lies near middle of valve.

Surface sparsely spinose, weakly rugose.

Relationships.—This species is recognized by its small size, truncated posterior margin, and spinose surface. It is represented in this collection by several, rather indistinct external molds of brachial valves.

Order SPIRIFERIDA

Superfamily ATRYPACEA

Genus ATRYPA Dalman

ATRYPA "RETICULARIS" (Linnaeus)

Pl. 10, fig. 9, 10

Anomia reticularis Linnaeus, 1767, p. 1132.

Atrypa Chemungensis Conrad, 1842, p. 265.

Atrypa reticularis Hall, 1852, p. 72, pl. 23, fig. 8; p. 270, pl. 55, fig. 5. — Hall, 1867, p. 316, pl. 52, fig. 1-3, 7-12; pl. 53, fig. 3-19; pl. 53A, fig. 22, 23. — Grabau and Shimer, 1909, p. 310, fig. 389 a-b, 392 a-c. — Prosser and Kindle, in Prosser, Kindle and Swartz, 1913, p. 183, pl. 16, fig. 4-6. — Cooper, in Shimer and Shrock, 1944, p. 319, pl. 121, fig. 1-3.

Shell medium to large in size, unequally biconvex, obovate in outline; greatest width one-third distance forward of beak; cardinal extremities regularly rounded; surface costate.

Brachial valve moderately convex; greatest convexity is 0.28 of valve length and located at middle of valve; viewed anteriorly, valve is moderately to strongly convex and only slightly flattened medially.

On the smaller of the two specimens showing external ornament, there are 30 costae, and on the larger specimen 37 costae; increase is by intercalation and bifurcation.

Single brachial valve measures 23.5 mm in length, 23.5 mm in width, and 1.0 mm in convexity.

Relationships.—Two species of *Atrypa* are recognized in the Mahantango Formation of south-central Pennsylvania, *Atrypa reticularis* and *A. spinosa.* The former is much more common and is recognized by its reticulate ornament that results from the intersection of the costae with numerous concentric laminae. *Atrypa spinosa,* on the other hand, has fewer costae, and the junctures of these with concentric laminae are produced, forming spines or nodes.

ATRYPA SPINOSA Hall

Pl. 10, fig. 11-13

Atrypa spinosa Hall, 1832, p. 200, fig. 1, 2.

Atrypa aspera Hall, 1857, p. 168. — Rogers, 1858, p. 828, fig. 671.

Atrypa spinosa vel. *A. aspera* Hall, 1867, p. 322, pl. 53A, fig. 1-14, 18, 24, 25.

Atrypa spinosa Schuchert, 1897, p. 156. — Grabau and Shimer, 1909, p. 311, fig. 391. — Cooper, in Shimer and Shrock, 1944, p. 319, pl. 121, fig. 4, 5.

Shell medium sized, biconvex, robust-ovoid in outline; greatest width just posterior to middle of shell; margins regularly rounded; length/width ratios average 0.98.

Pedicle valve slightly less convex than brachial valve; greatest convexity ranging from one-sixth to less than one-third of valve length; length/width ratios average 1.0 for 4 specimens; hinge line short, about one-half of valve width; extremities curving into lateral margins of valve; sulcus faint, broad.

Brachial valve convex to gibbous; greatest convexity equals from 0.30 to 0.40 of valve length; fold very faint, broad.

Surface bears 15 to 18 rounded costae which increase by bifurcation toward anterior margin; concentric striae fine, superimposed on prominent concentric lamellae; spines developed at intersection of concentric lamellae and radial costae.

Pedicle valve: length—18.0 to 26.0 mm; width—18.5 to 26.0 mm; convexity—3.0 to 6.0 mm.

Relationships.—This species is readily distinguished from *Atrypa reticularis* by its ornament consisting of coarser and fewer costae crossed by more numerous concentric lamellae. Surficial spines, features so typical for this species, are not observed on exfoliated specimens. However, the spines can be seen on specimens that are still contained in their surrounding sedimentary matrix.

Genus Pustulatia Cooper

Pustulatia pustulosa (Hall)

Pl. 10, fig. 14-18

Vitulina pustulosa Hall, 1860, p. 82. — Hall, 1867, p. 410, pl. 62, fig. 1, a-i. — Grabau and Shimer, 1909, p. 351, fig. 458.

Pustulina pustulosa Cooper, in Shimer and Shrock, 1944, p. 319, pl. 121, fig. 33-37.

Pustulatia pustulosa Cooper, 1956, p. 769.

Shell small, plano-convex, semicircular in outline; greatest width at or anterior to hinge.

Pedicle valve depressed convex; greatest convexity at or just slightly forward of posterior margin; length/width ratios average 0.74; smaller specimens proportionately longer, with ratios greater than 1.00; fold is about one-fifth of valve width at anterior margin.

Brachial valve flat to depressed convex; length/width ratios average 0.75; smaller specimens are proportionately longer; sulcus about one-third of valve width at anterior margin.

Surface bears from 8 to 10 plications; plications strong, rounded, separated by rounded to subangular furrows; fold of pedicle valve bears 2 plications separated by shallow furrows; sulcus of brachial valve bears weak plication along mid-line; concentric growth lines fine; pustules somewhat elongate, radially disposed, fine, cover entire surafce, equant and more numerous toward margins.

Pedicle valve: length—3.5 to 7.0 mm; width—3.0 to 10.0 mm; convexity—0.5 to 1.5 mm.

Relationships.—Pustulatia pustulosa is readily recognized by its small size, and by its sparsely but strongly plicate surface blanketed with minute pustules. Larger specimens typically are more transverse than smaller forms. The character of the fold is variable; some specimens have obviously furrowed folds, and others have only a suggestion of this medial furrowing.

Superfamily SPIRIFERACEA

Family SPIRIFERIDAE

Subfamily EOSPIRIFERINAE

Genus DELTHYRIS Dalman

DELTHYRIS SCULPTILIS Hall

Pl. 10, fig. 19-22

Delthyris sculptilis Hall, 1843, p. 202.

Spirifera sculptilis Hall, 1867, p. 221, pl. 35, fig. 10-14.

Spirifer sculptilis Hall and Clarke, 1893, pl. 37, fig. 8. — Grabau and Shimer, 1909, p. 331, fig. 422, c, d.

Shell small to medium in size, biconvex, subtriangular to subsemi-elliptical in outline; greatest width at hinge; surface plicate and laminate.

Pedicle valve moderately convex; length/width ratios average 0.70; sharply sulcate.

Brachial valve less convex than pedicle valve.

Surface plicate; plications angular, number 4 to 5 on each lateral slope; median fold and sulcus nearly twice as broad as adjacent plications; concentric laminae closely and more or less equally spaced, number 3 to 4 per 2 mm; very fine concentric striae on few specimens; delicate spines on surface of single specimen.

Pedicle valve: length—6.0 to 8.0 mm; width—10.0 to 12.0 mm; convexity—2.0 mm.

Relationships.—Specimens in this collection referred to *Delthyris sculptilis* show a rather wide range of characters, and, therefore, may, with further study, prove to belong to more than one species, or more than one subspecies. *Delthyris sculptilis* is readily recognized by its subtriangular,

somewhat mucronate outline and its very strikingly angular external ornament, consisting of coarse radial plicae and strong concentric laminae. *Delthyris consobrinus* and *D. zic-zac* both have finer and more numerous radial plicate and concentric lamellae.

Subfamily RETICULARIINAE

Genus ELYTHA Fredericks

ELYTHA FIMBRIATA (Conrad)

Pl. 10, fig. 23-27

Delthyris fimbriatus Conrad, 1842, p. 263. — Hall, 1843, p. 208, fig. 10.
Spirifera fimbriata Hall, 1867, p. 314, pl. 33, fig. 1-11.
Spirifer fimbriatus Hall and Clarke, 1893, pl. 36, fig. 17-22; pl. 38, fig. 9, 10.
Reticularia fimbriata Schuchert, 1897, p. 342. — Grabau and Shimer, 1909, p. 338, g. 431, a, b.
Spirifer (Reticularia) fimbriatus Prosser and Kindle, in Prosser, Kindle and Swartz, 1913, p. 197, pl. 19, fig. 10-12.
Elytha fimbriata Cooper, in Shimer and Shrock, 1944, p. 327, pl. 126, fig. 1-3.

Shell medium in size, biconvex, subsemielliptical to suborbicular in outline; greatest width one-tenth of valve length forward of posterior margin; hinge width slightly less than greatest width; surface spinose.

Surface of shell concentrically lamellose; lamellae equally spaced, about 1 mm apart, bear closely spaced, double-barrelled spines; spines on anterior margin about 2 mm long; faint concentric undulations on lateral slopes.

Pedicle valve: length—12.0 mm; width—13.0 mm; convexity—3.0 mm.

Relationships.—The double-barrelled spines that blanket the surface of *Elytha fimbriata* are the most diagnostic features of this species. No other species in the Mahantango Formation of south-central Pennsylvania even vaguely resembles *E. fimbriata.*

Genus EMMANUELLA Grabau

EMMANUELLA SUBUMBONA (Hall)?

Pl. 11, fig. 1, 2

Orthis subumbona Hall, 1857, p. 168.
Ambocoelia subumbona Hall, 1860, p. 71.
Spirifera subumbona Hall, 1867, p. 234, pl. 33, fig. 22-30.
Martinia subumbona Miller, 1889, p. 352. — Schuchert, 1897, p. 264.
Emmanuella subumbona Cooper and Williams, 1935, pl. 59, fig. 8, 12. — Cooper, in Shimer and Shrock, 1944, p. 329, pl. 126, fig. 32, 33.

Shell small, unequally biconvex, subpentagonal in outline; greatest width at or slightly anterior to hinge; cardinal extremities form right angles, sharply rounded; surface nearly smooth.

Pedicle valve very convex; greatest convexity equals 0.33 of valve length, located just anterior of beak; antero-lateral margins regularly rounded; length/width ratios average 0.90 for 6 specimens; beak extends slightly behind hinge; interarea high, strongly arcuate so that beak is directed dorsally or posterodorsally; sulcus weak.

Brachial valve moderately convex; greatest convexity near middle of valve; interarea with open notothyrium.

Surface smooth or bearing weak concentric growth lines.

Interior of pedicle valve bears cardinal teeth; muscle scars narrow, cordate, deeply excavated posteriorly.

Interior of brachial valve bears divergent socket plates and thin, subparallel crural lamellae that nearly conjoin at the base of the valve.

Pedicle valve: length—5.5 to 7.5 mm; width—5.0 to 9.5 mm; convexity—1.5 to 3.0 mm.

Relationships.—The shell outline, weakly sulcate profile, smooth exterior, presence of divergent socket plates, and lack of a median septum in the brachial valve distinguish this species from *Ambocoelia umbonata*, which is strongly sulcate and has a brachial septum, and from *Echinocoelia ambocoeloides*, which is spinose and also possesses a median septum on the brachial valve. Cooper and Williams (1935) mention the kinship of *Emmanuella subumbona* with these two species, and it seems plausible that, owing to the similarities between these three species, they represent branches from a common stem.

Emmanuella pennsylvanica Willard

Pl. 11, fig. 3-6

Emmanuella pennsylvanica Willard, 1937, p. 1252, pl. 2, fig. 10, 25-27. — Cooper, in Shimer and Shrock, 1944, p. 329, pl. 126, fig. 38, 39.

Shell medium-sized, biconvex, transversely subpentagonal in outline; greatest width between one-fourth and one-half of shell length forward of posterior margin; surface smooth.

Pedicle valve moderately gibbous; length/width ratios for 8 specimens average 0.38; smaller forms relatively more transverse than larger forms; anterior margin only faintly sulcate.

Brachial valve moderately convex; length/width ratios for 8 specimens average 0.79.

Surface smooth except for faint concentric growth lines.

Pedicle valve: length—7.5 to 19.0 mm; width—9.0 to 20.0 mm; convexity—3.5 to 12.0 mm.

Relationships.—This species, much like *Emmanuella subumbona* except for size, may very well represent the mature form of that species. The smallest specimen of *E. pennsylvanica* is indistinguishable from specimens of *E. subumbona* from New Bloomfield. Internal features may be useful in differentiating these two species, but only exteriors of *E. pennsylvanica* have been collected.

Subfamily SPIRIFERINAE

Genus PARASPIRIFER Helmbrecht and Wedekind

PARASPIRIFER ACUMINATUS (Conrad)

Pl. 11, fig. 7

Delthyris acuminata Conrad, 1839, p. 65.
Spirifer acuminata Hall, 1857, p. 135.
Spirifera acuminata Hall, 1867, p. 198, 234, pl. 29, fig. 9-18; pl. 35, fig. 24.
not *Spirifera acuminata* Lesley, 1889, p. 995, text fig.
Spirifer acuminatus Hall and Clarke, 1893, p. 31, 39, pl. 39, fig. 39-42. — Schuchert, 1897, p. 380. — Grabau and Shimer, 1909, p. 326, fig. 414. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 193, pl. 18, fig. 10.
Paraspirifer acuminatus Cooper, in Shimer and Shrock, 1944, p. 323, pl. 123, fig. 3-5.

Brachial valve large, subquadrate in outline; length/width ratio for 1 specimen is 0.65; viewed anteriorly, valve is extremely carinate; greatest convexity equals 0.65 of valve length for single specimen, located two-thirds of valve length forward of posterior margin; greatest width anterior to middle of valve; beak extends nearly one-fifth of valve length behind hinge; fold angular, grades imperceptibly onto lateral slopes, equal 0.40 of valve width at anterior margin, lacks radial ornament; costae broad, bifurcating, number 17 on each lateral slope.

Brachial valve: length—31 mm; width—48 mm; hinge width—43 mm; convexity—19 mm; fold width—19 mm.

Relationships.—This species is characterized by its carinate profile, subquadrate outline, and bifurcating radial costae. Specimens of *Spinocyrtia granulosa clintoni* approach this species in the carinate profile, but the granulose surface and furrowed fold on the brachial valve of that species are distinguishing features.

Unfortunately, pedicle valves of this species have not been collected and described.

Genus SPINOCYRTIA Fredericks

SPINOCYRTIA GRANULOSA (Conrad)

Pl. 11, fig. 8-14

Delthyris granulosa Conrad, 1839, p. 65.
Delthyris congesta Rogers, 1858, p. 828, fig. 670, 673.
Spirifera granulifera Hall, 1867, p. 223-225, pl. 36, fig. 1-13.
Spirifera oweni Hall, 1867, p. 197, pl. 29, fig. 1-8. — Hall and Clarke, 1893, pl. 22, fig. 1-7.
Spirifer granulosus Hall and Clarke, 1893, p. 29-31, 39, pl. 23, fig. 1-15; pl. 29, fig. 9-12. — Grabau and Shimer, 1909, p. 328, fig. 417. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 190, pl. 18, fig. 1-6.
Spinocyrtia granulosa Cooper, in Shimer and Shrock, 1944, p. 323, pl. 123, fig. 6-8.

Shell large, nearly equally biconvex, subquadrate in outline; surface plicate.

Pedicle valve very convex; greatest convexity equals 0.37 of valve length; length/width ratios 0.79 for 2 specimens; sulcus well defined, with gently rounded margins, width equals 0.4 of valve width at anterior margin.

Brachial valve extremely gibbous; greatest convexity equals 0.66 of valve length; length/width ratio for one specimen is 0.59; fold high, sharply rounded, grades onto lateral slopes toward anterior margins, equals 0.3 of valve width at anterior margin, medially furrowed.

Surface plicate; plicae broad, rounded, number 14 to 18 per valve, spaced 3 or 4 per 10 mm at anterior margin; concentric striae fine, widely fasciculate; very fine radial striae and somewhat elongate granules superimposed on plicae.

Interior of pedicle valve bears cardinal teeth supported by plates; dental plates short, strong, divergent; delthyrial cavity partially filled; diductor scars pyriform in outline, posteriorly deep, anteriorly shallow, split by short median elevation.

Pedicle valve: length—37.0 to 46.0 mm; width—49.0 to 56.0 mm; convexity—13.5 to 18.0 mm.

Relationships.—*Spinocyrtia granulosa* is characterized by its large size, subquadrate outline, broad and moderately shallow sulcus, high and furrowed fold, and, particularly, by the very fine radial striae and elongate granules. Specimens of this species in this collection differ somewhat from *Spirifera granulifera* as described and illustrated by Hall (1867, p. 223, 224; pl. 36) in having the greatest width anterior to, rather than at, the hinge, and in having 14 to 18, rather than 20 to 22, costae. Criteria used in the present study for differentiating the three subspecies of *S. granulosa* are summarized in the accompanying table.

Subspecies	*Surface ornament*	*Sulcus*
S. granulosa	granulose	broad, gently concave
S. granulosa clintoni	striato-granulose	deep, subangular
S. granulosa girtyi	striate	subangular

Spinocyrtia granulosa clintoni (Hall)

Pl. 11, fig. 15-17

Spirifer clintoni Hall, 1857, p. 157.
Spirifera granulifera var. *clintoni* Hall, 1867, p. 225, pl. 37, fig. 1-4.

Relationships.—This subspecies is, in all respects, like *Spinocyrtia granulosa,* except for the more angular and generally deeper sulcus, and the scarcity of well defined granules. This apparent scarcity of granules, however, may be the result of the mode of preservation. Specimens referred to this subspecies are identical, except for a somewhat smaller size, with specimens of *Spirifera granulifera* var. *clintoni* illustrated by Hall (1867, pl. 37, fig. 1-4).

Inasmuch as the specimens referred to this taxon usually are separated stratigraphically from specimens of *S. granulosa* and *S. granulosa girtyi,* it has been deemed advisable to regard the specimens are representing a subspecies rather than a variety as proposed by Hall.

Although this subspecies is abundant in some sections, specimens are too incompletely preserved to permit reliable measurement.

Spinocyrtia granulosa girtyi Ellison n. subsp.

Pl. 11, fig. 18-20

Shell large, subequally biconvex, subquadrate to semicircular in outline; greatest width at hinge; cardinal extremities somewhat produced; surface costate.

Pedicle valve very convex; greatest convexity equals about one-third of valve length, located slightly behind middle of valve; length/width ratio for one specimen 0.78; beak extends one-third of valve length behind hinge, obtuse in outline, moderately incurved; cardinal slopes broadly concave; interarea high, obtuse with commissure, concave, with apical portion subparallel to commissure; delthyrium triangular, as wide as high, open; sulcus subangular, with margins poorly defined, width one-third of greatest valve width at anterior margin; lateral slopes flattened, somewhat deflected toward cardinal extremities.

Brachial valve poorly represented in collection, apparently very convex, more transverse in outline than pedicle valve.

Surface bears an average of 17 plicae on each lateral slope; plicae subequal with intervening furrows near cardinal slopes, but more broadly rounded and much wider than furrows toward median sulcus and anterior margin, spaced 4 per 6 mm at anterior margin; very fine radial striae, especially in furrows between plicae; granules faintly defined on pedicle valve, well defined on brachial valve.

Interior of pedicle valve bears teeth supported by strong, slightly divergent dental plates; plates extend nearly to middle of valve; diductors scars subelliptical in outline, more than one-half as wide as valve, less than one-third as long as valve, separated posteriorly by medial extension of apical callosity; adductor scars poorly defined; surface ornament scarcely discernible internally.

Interior of brachial valve bears strong, widely divergent socket plates; muscle areas relatively small, widely separated on either side of posterior portion of median septum; median septum long, broad, thickens posteriorly, measures more than one-half of valve length; external ornament reflected over most of valve interior.

Measurements are given in table 7.

Relationships.—This subspecies is distinguished from *Spinocyrtia granulosa* and *S. granulosa clintoni* by features indicated in the table accompanying the discussion of relationships of *S. granulosa.* Specimens referred to this subspecies are somewhat smaller than those of the other subspecies, and the brachial valve has a strong, thick median septum. The nature of the sulcus is much like that of *S. granulosa clintoni,* but somewhat less angular, and this subspecies shows no indication of surface granulosity. This latter feature may be attributed to the preservation. Establishing these three subspecies involves some uncertainty, attendant with limited collections of only moderately well preserved specimens.

Figured specimens of this new subspecies are deposited in the U. S. National Museum.

Genus Mucrospirifer Grabau

Mucrospirifer mucronatus (Conrad)

Pl. 12, fig. 1-12

Delthyris mucronata Conrad, 1841, p. 54.
Spirifer mucronata Rogers, 1858, p. 828, fig. 668.
Spirifera mucronata Hall, 1867, p. 216, pl. 34, fig. 1-32.
Spirifer mucronatus Hall and Clarke, 1893, p. 14, 17, 36, pl. 29, fig. 8; pl. 34, fig. 13-22.
Spirifer pennatus Schuchert, 1897, p. 401.
Spirifer mucronatus Grabau and Shimer, 1909, p. 330, fig. 421. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 187, pl. 17, fig. 10-18.
Mucrospirifer mucronatus Cooper, in Shimer and Shrock, 1944, p. 321, pl. 122, fig. 4-6.

Shell moderate in size, biconvex, alate to subalate in outline; cardinal extremities commonly extended and hinge is position of greatest width.

Pedicle valve gently convex; length/width ratio commonly 0.4; shallow and narrow sulcus.

Surface of valves bears 11 to 16 plications on either slope, becoming obsolete on cardinal extremities; costae and furrows subangular and of nearly same breadth; fold and sulcus bear faint single median plication; concentric lamellae closely and equally spaced, about 4 per 1 mm along medial line.

Pedicle valve: length—7.5 to 19.0 mm; width—20.0 to 58.0 mm; convexity—1.5 to 4.0 mm.

Relationships.—This ubiquitous species exhibits considerable variation in convexity, length/width ratio, character of the fold and sulcus, and nature of the external ornament (see plate 12). Within this variation, no definite trends have been recognized, but several relationships have been noted. Specimens from the upper part of the Frame Member at Huntingdon are not as wide, neither absolutely nor proportionately, as specimens collected from beds of siltstone or sandstone at other sections. Specimens from 896 feet above the base of the described section at Websters Mill are proportionately longer and have a more distinctly furrowed fold than nearly all other specimens collected. Furthermore, ribs on either side of the sulcus on the specimens from this level at Websters Mill are not deflected laterally as they are on most specimens collected. The length/width ratios for specimens collected from shale and claystone are somewhat smaller than for specimens from sandstone and siltstone.

At this time, no valid basis is recognized for establishing subspecies or separate species within the species *Mucrospirifer mucronatus.* More extensive sampling and more intensive study of local populations may reveal differences useful in differentiating smaller taxa.

Genus Mediospirifer Bublichenko

The genus Mediospirifer as originally defined by Bublichenko (1956) occurs in the Middle and Upper Devonian and includes the North American species *Mediospirifer audaculus* (Hall) and *Mediospirifer audaculus macronotus* (Hall), as well as several European species. This species is distinguished from the Lower and Middle Devonian genus *Brachyspirifer* Wedekind by its larger size, its more extended hinge line, the presence of deltidial (delthyrial) plates, and the absence of a fimbriate surface texture.

In the present collection, several new species have been referred to the genus *Mediospirifer.* None of these species is fimbriate; deltidial plates are present on specimens of *M. audaculus* and *M. belliplicata,* but specimens of the other species do not preserve these plates. Furthermore, all

species here referred to *Mediospirifer* have radial plications that bear fine grooves along their summits, and some have brachial folds that are medially furrowed. The grooves on the plications are especially noticeable on the more medially situated plications. The following table summarizes the characteristics of the species of *Mediospirifer* occurring in the Mahantango Formation of south-central Pennsylvania.

Characteristic	Species				
	audaculus	*belli-plicata*	*millers-townensis*	*drom-goldi*	*belli-tropis*
Pedicle valve:					
Length/width	0.54	0.72	0.78	0.85	0.69
Convexity/length	0.35	0.37	0.38	0.42	0.39
Greatest width	hinge	hinge	anterior to hinge	hinge	hinge
Cardinal angle	flattened	flattened	not flattened	not flattened	slightly flattened
Sulcus depth	moderate	shallow-moderate	shallow	shallow	shallow-deep
Plications	15-23	9-12	9-15	7-9	11-16
Brachial valve:					
Fold height	low-moderate	moderate; faintly furrowed	low; furrowed	high	high

Figured specimens of new species of *Mediospirifer* that are described here are deposited in the U. S. National Museum.

Mediospirifer audaculus (Conrad)

Pl. 12, fig. 13-18

Delthyris audacula Conrad, 1842, p. 262.
Spirifer medialis Hall, 1857, p. 157.
Spirifera medialis Hall, 1867, p. 227, pl. 38, fig. 1-22.
Spirifer audaculus Hall and Clarke, 1893, p. 29, pl. 24, fig. 1-13; pl. 29, fig. 5. — Schuchert, 1897, p. 382. — Grabau and Shimer, 1909, p. 329, fig. 420, a. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 192, pl. 18, fig. 7-9.
Brachyspirifer audaculus Cooper, in Shimer and Shrock, 1944, p. 323, pl. 123, fig. 12, 13.
Mediospirifer medialis Bublichenko, 1956, p. 102.

Shell medium to large in size, subequally biconvex, semicircular to semielliptical in outline; greatest width at hinge; cardinal extremities acute, commonly acuminate to mucronate; surface plicate.

Pedicle valve very convex; maximum convexity equals 0.35 of valve length; length/width ratios average 0.54; interarea very high, wide, normal to very obtuse with commissure, regularly concave to nearly flat; delthyrium triangular, as wide as high, half closed by apical callosity or deltidial plates; sulcus well defined, sharply to regularly concave, moderately deep with angular margins, width at anterior margin 0.20 greatest width of valve; lateral slopes flattened toward lateral margins and cardinal extremities.

Brachial valve very convex, but somewhat less convex than pedicle valve; fold well defined, with angular margins, low to moderately high, regularly and even sharply convex to flattened along summit, width at anterior margin 0.24 of greatest valve width.

Surface bears 15 to 33, averaging 18 to 19 rounded plications of uniform strength; medial plicae spaced 5 to 11 per 10 mm at anterior margin; concentric laminae widely spaced except at anterior margin; summits of medial plicae on many specimens marked with fine, thread-like grooves.

Interior of pedicle valve bears simple teeth supported by strong, divergent dental plates; delthyrial cavity filled with apical callosity; diductor scars subsemicircular in lateral outline, somewhat broader than sulcus, surround narrow, V-shaped adductor scars.

Pedicle valve: length—14.0 to 33.0 mm; width—29.0 to 50.0 mm; convexity—5.0 to 10.0 mm.

Relationships.—This species, one of the most common in the Mahantango Formation, is readily recognized by its well defined sulcus with angular margins, the imbricate nature of the anterior margin, the strong dental plates, and the apcal callosity of the delthyrial cavity. It is closely related to *Mediospirifer millerstownensis* and *M. bellitropis*, but the former has rounded cardinal extremities and is not flattened toward the lateral margins, and the latter is more convex and not flattened toward the lateral margins. Although the number of nearly complete valves in this collection is rather meager and average valves may be subject to question, it appears that larger specimens are relatively more elongate and have a more rapidly expanding sulcus than smaller specimens. Small brachial valves are somewhat less convex than large ones.

Hall's (1867) description of *Mediospirifer audaculus ("Spirifer medialis")* indicates that his New York specimens possess proportionately broader delthyria and more numerous plications (20-30 vs. 15-23) than the material described in the present report. The difference in number of plications may be due wholly or in part to the fact that in the present study plication counts often had to be made on internal molds rather than external molds or shell material.

Mediospirifer audaculus macronotus (Hall)

Pl. 12, fig. 19, 20

Delthyris macronota Hall, 1843, p. 206, fig. 5.
Spirifera macronota Hall, 1867, p. 231, pl. 38A, fig. 1-22.
Spirifer audaculus var. *macronotus* Hall and Clarke, 1893, pl. 24, fig. 18-27.
Spirifer audaculus macronotus Schuchert, 1897, p. 383.

Shell large, subequally biconvex, semielliptical in outline; greatest width at hinge; cardinal extremities acuminate; surface plicate.

Pedicle valve very convex; beak erect; interarea very high, measuring 13 mm by 44 mm on single specimen, perpendicular to commissure, flat except for slight concavity in apical portion; sulcus shallow, expands anteriorly.

Brachial valve less convex than pedicle valve; fold low.

Surface plicate; plicae rounded, broader than furrows, number approximately 17 on each lateral slope; concentric laminae widely spaced.

Pedicle valve: length—no measurement; width—44 mm; convexity—13 mm.

Relationships.—This subspecies is represented in this collection by one nearly complete shell, and several fragments. However, the nearly complete shell is halved transversely so that no measurement of the length is possible. The subspecies differs from *M. audaculus* in its nearly erect beak, and high, flat interarea.

Mediospirifer bellitropis Ellison n. sp.

Pl. 12, fig. 21-25

Shell medium to large in size, equally biconvex, semicircular to subsemielliptical in outline; greatest width at the hinge; cardinal extremities form right angles, acuminate; surface plicate.

Pedicle valve very convex; maximum convexity averages 0.39 of valve length, situated between one-fourth and one-third of valve length forward of beak; length/width ratios average 0.69 for three specimens; smaller forms proportionately wider than larger forms; beak one-fourth to one-fifth of valve length behind hinge, moderately incurved, obtuse in outline; cardinal slopes concave, subparallel to hinge toward cardinal extremities; interarea high, obtuse to nearly parallel with commissure, strongly concave; delthyrium triangular, about twice as wide as high, apical half filled with shelly callosity; sulcus well defined, variable in depth from shallow to deep, shallower in posterior half of valve, regularly concave to subangular; lateral margins subrounded to subangular, one-

fourth to one-third of greatest width at anterior margin; larger specimens scarcely flattened toward lateral margins.

Brachial valve as convex as pedicle valve; maximum convexity averages 0.38 of valve length, located about 0.4 of valve length from posterior margin; length/width ratios average 0.67 for three rather uniform specimens; beak scarcely extends behind hinge, very obtuse in outline; cardinal slopes straight, parallel to hinge except for small beak area; interarea unknown; fold well defined, high, subangular giving valve a carinate appearance in anterior profile; lateral margins flatten gently.

Surface with 11 to 16, averaging 13 rounded to subangular plicae; concentric laminae present, but poorly defined.

Interior of pedicle valve with short, strong dental plates bounding delthyrial cavity and posterior half of muscle areas; diductor scars subquadrangular, measures 0.4 of greatest width across, extend more than two-thirds of valve length; adductor scars narrow, separated posteriorly by low median septum continuous with apical callosity; surface ornament reflected internally.

Interior of brachial valve unknown.

Measurements of specimens of *M. bellitropis* are given in table 7.

Relationships.—This species is characterized by the carinate aspect of the brachial valve with its high unfurrowed fold as well as by the very convex pedicle valve with its subangular, relatively broad sulcus. Only *Mediospirifer dromgoldi* has a similar brachial profile, but that species has fewer ribs on each lateral slope and is more convex and relatively longer. In addition, most specimens of *M. dromgoldi* in this collection are smaller than specimens of *M. bellitropis*. The possibility presents itself that these are perhaps but growth stages. However, small specimens of *M. bellitropis* are proportionally longer than large specimens, whereas specimens of *M. dromgoldi* are smaller than this species and proportionally wider. There is, therefore, some reason for not considering specimens referred to *M. dromgoldi* as being young of *M. bellitropis*. No descriptions nor illustrations of *"Spirifer"* species of Hall nor of Kindle and Prosser correspond to this species. It resembles *Mediospirifer audaculus* in many respects except for its high, unfurrowed fold on a more convex brachial valve.

Mediospirifer dromgoldi Ellison n. sp.

Pl. 12, fig. 26-31

Shell medium to large, biconvex, subquadrate in outline; lateral margins regularly curving; anterior margin medially produced; greatest width anterior to or at the hinge.

Pedicle valve moderately gibbous; maximum convexity equals 0.42 of valve length, located one-third of valve length forward of posterior margins; length/width ratios average 0.85; interarea broadly to regularly concave, moderately high, obtuse; delthyrium nearly twice as high as wide, varies from almost completely open to nearly closed; median sulcus shallow, flattened or subangular, with faint median groove.

Brachial valve very convex; maximum convexity located between one-third and one-half of valve length forward of beak; length/width ratios average 0.68; interarea very low, narrow; notothyrium half as wide, open; median fold high, sharply rounded.

Surface bears 7 to 9 ribs on each slope; ribs relatively broader than intervening furrows; medial 6 or 8 ribs bear faint radial grooves toward anterior margin; concentric ornament lacking except for widely spaced growth lamellae on few specimens.

Interior of pedicle valve bears strong teeth supported by dental lamellae which extend about one-half length of valve and diverge slightly; muscle areas subelliptical in outline; adductor, diductor, adjustor scars poorly defined in specimens; callosity nearly fills delthyrial cavity, partially closes delthyrium.

Interior of brachial valve bears dental sockets bounding notothyrium; surface ornament reflected internally.

Measurements of specimens of *Mediospirifer dromgoldi* are given in table 7.

Relationships.—The relatively high, sharply convex, unfurrowed fold of the brachial valve is a diagnostic feature of this species and serves to distinguish it from all other spirifers in this collection except *Mediospirifer bellitropis.* Pedicle valves of that species, however, are less convex, more transverse in outline, and the sulcus is deeper than in *M. dromgoldi.*

Mediospirifer bellplicata Ellison n. sp.

Pl. 13, fig. 1-5

Shell medium in size, unequally biconvex, semicircular in outline; greatest width at hinge; cardinal extremities acute, acuminate in some specimens; surface plicate.

Pedicle valve very convex; maximum convexity averages 0.37 of valve length, located one-third of valve length forward of beak; in anterior profile, valve is somewhat flattened and even concave toward lateral margins; length/width ratios average 0.72; beak extends nearly one-fourth of valve length behind hinge, moderately incurved, normal to obtuse in outline; cardinal slopes convex along medial third of valve on either side of beak, remainder nearly parallel to hinge and slightly concave;

interarea high, wide, obtuse to nearly parallel to commissure, sharply concave; delthyrium about twice as wide as high, partially to almost totally closed by apical shelly callosity; sulcus well defined, moderately deep to shallow, sharply to regularly concave or flattened, margins subangular to rounded.

Brachial valve depressed convex to moderately convex; maximum convexity located near middle of valve; beak scarcely extends behind hinge; cardinal slopes parallel to hinge; fold well defined, sharply rounded to flattened with faint medial depression, width about one-sixth of greatest width at anterior margin.

Surface bears 9 to 12 subangular to rounded plications; plicae number 6 to 12 per 10 mm, more widely spaced on larger specimens; concentric laminae irregularly spaced; some specimens possess medial plicae, summits of which are finely grooved.

Interior of pedicle valve with short, strong dental plates; callosity fills delthyrial cavity, expressed externally as deltidial plates; muscle area confined to sulcus, longitudinally subelliptical, with short median septum separating posterior portions of muscle pairs, longitudinally or radially striate; external ornament reflected internally.

Interior of brachial valve with well defined socket plates; cardinal process striate; median septum very low, thin, extends to or beyond middle of valve.

Measurements of specimens of *M. belliplicata* are given in table 7.

Relationships.—This species resembles *Mediospirifer audaculus* in nearly every respect except for its less transverse form and less numerous plications. The character of the fold and sulcus, external ornament, internal features such as strong dental plates and partially filled delthyrium, as well as the fine grooves evident on some specimens, along the crests of medial plications, are identical with those of *M. audaculus,* suggesting a close relationship between these two species. *Mediospirifer belliplicata* also bears a similarity with *Spirifer formosa* Hall, but that species has a lower fold and more numerous plications.

Mediospirifer millerstownensis Ellison n. sp.

Pl. 13, fig. 6-10

Shell large, unequally biconvex, subpentagonal in outline; greatest width one-third distance from hinge toward anterior margin; cardinal extremities normal to obtuse, rounded; surface plicate.

Pedicle valve very convex; maximum convexity equals 0.38 of valve length, located between one-fourth and one-half of valve length forward of beak; viewed anteriorly, valve is carinate; lateral margins not flattened;

length/width ratios average 0.78; beak extends about one-fourth of valve length behind hinge, moderately incurved, normal to obtuse in outline; cardinal slope slightly concave; interarea high, wide, obtuse, regularly concave; delthyrium not observed; sulcus well defined, moderately shallow, regularly concave, expanding anteriorly to between one-fourth and one-third of valve width.

Brachial valve moderately to very convex; maximum convexity located at or posterior to center of valve; length/width ratios average 0.64; beak scarcely extends behind hinge, very obtuse in outline; cardinal slopes nearly straight; interarea and notothyrium unknown; fold well defined, moderately low, regularly convex to flattened along the summit, expanding anteriorly to about two-fifths of valve width; faint furrow extends one-half length of valve along fold.

Surface bears from 9 to 15 rounded plicae, separated by narrow furrows on each flank; summit of medial plicae radially grooved in some specimens; concentric growth varies near anterior margins on few specimens.

Interior of pedicle valve bears strong, divergent dental lamellae extending nearly one-third of valve length; muscle areas poorly defined.

Interior of brachial valve bears small, posteriorly directed, arrowhead-shaped muscle scars; median septum low, narrow, extends one-half length of valve.

Measurements of specimens are given in table 7.

Relationships.—Mediospirifer millerstownensis, although similar in many respects to other Mahantango spirifers is characterized chiefly by its low, broad and slightly flattened fold which is faintly furrowed. Such a feature serves to distinguish this species from *M. dromgoldi, M. bellitropis,* and *M. audaculus.* The apparent lack of any fine surface ornament distinguishes it from *Spinocyrtia granulosa, S. granulosa clintoni* and *S. granulosa girtyi.* Grooves along the crests of some medial plicae suggest a kinship to *Mediospirifer audaculus* with which it is most easily confused. However, in addition to the difference in the character of the fold, *Mediospirifer millerstownensis* differs from *M. audaculus* in being less transverse in outline, in having rounded cardinal extremities and in not being flattened toward the lateral margins.

Mediospirifer angustus (Hall)?

Pl. 13, fig. 11

Spirifer angusta Hall, 1857, p. 164, text fig.
Spirifera angusta Hall, 1867, p. 230, pl. 38, fig. 23-32.
Spirifer angustus Hall and Clarke, 1893, p. 31, pl. 24, fig. 14-17. — Schuchert, 1897, p. 381. —Grabau and Shimer, 1909, p. 330, fig. 420, b.

— Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 196, pl. 19, fig. 8, 9.

Pedicle valve small, alate in outline, with plicate surface; interarea high, strongly acute, nearly flat; delthyrium high, narrow, open; plicae number at least 7 on either side of well-defined sulcus.

Pedicle valve: length—7.5 mm; width—18 mm; convexity—4 mm.

Relationships.—This species is represented by one internal mold of a pedicle valve. *Mediospirifer angustus?* differs from similar species in the Hamilton Group in its strongly acute interarea.

Genus Fimbrispirifer Cooper

Fimbrispirifer venustus (Hall)

Pl. 13, fig. 12, 13

Spirifer venustus Hall, 1860, p. 82.

Fimbrispirifer venustus Cooper, 1942, p. 231. — Cooper, in Shimer and Shrock, 1944, p. 323, pl. 122, fig. 32-33.

Shell medium to large, biconvex, subsemielliptical in outline; cardinal extremities sharply rounded; surface costate and concentrically fimbriate.

Surface bears bifurcating and trifurcating costae numbering 1 per 1 mm at anterior margin; lateral slopes with 8 to 12 costae each; thin, closely spaced, zig-zag, concentric lamellae.

Pedicle valve: length—10.5 mm; width—18 mm; convexity—3.5 mm.

Relationships.—The specimens of *F. venustus* in this collection, although not preserving the spinose fringes that typically ornament the concentric lamellae of this species, resemble very closely in other aspects the specimens illustrated and described in Shimer and Shrock's *Index Fossils of North America* (pl. 122, fig. 32-34). This species differs from *F. divaricatus* in possessing finer costae and a lower fold.

Genus Tylothyris North

Tylothyris pauliformis (J. S. Williams)

Pl. 13, fig. 14, 15

"Spirifer" pauliformis Williams, in Cooper and Williams, 1935, p. 842, pl. 59, fig. 3, 4, 5, 29.

Shell small, biconvex, subsemielliptical in outline, alate; greatest width at hinge; cardinal extremities acute, slightly mucronate; anterior and lateral margins corrugate.

Pedicle valve moderately convex; sulcus well defined, width equals one-fifth of valve width at anterior margin; length/width ratio for one specimen 0.50.

Brachial valve depressed convex to moderately convex; fold only slightly more prominent than radial plicae, equals about one-sixth of valve width; length/width ratios for 3 specimens average 0.40.

Surface plicate; plicae angular, spaced 1 per 1 mm at anterior margin, with subequal intervening furrows; fine, radiating lirae cover ribs and furrows; concentric lamellae produce zig-zag appearance, spaced 2 to 4 per 1 mm, most widely spaced at anterior margin; 3 to 5 fine lirae between adjacent lamellae.

Pedicle valve: length—5 mm; width—11 mm.

Relationships.—Tylothyris pauliformis is represented in this collection by numerous internal and external molds, most of which are incomplete. It is an especially small spiriferid, a feature which helps distinguish it from *Delthyris sculptilis*, a species to which *T. pauliformis* bears a strong resemblance, by virtue of the zig-zag surface sculpture. In addition, *T. pauliformis* also has more widely spaced concentric lamellae than *D. sculptilis*, and bears concentric and radiating lirae, whereas *D. sculptilis* does not.

In New York State, this is a Tully species, being especially common in the West Brook Member of Cooper and Williams (1941). Its occurrence in the uppermost part of the Mahantango Formation in Pennsylvania, along with many other species found in the West Brook Member of the Tully in New York, suggests a closer stratigraphic relationship between these two units than is presently appreciated.

"Spirifer" tullius Hall

Pl. 13, fig. 16-18

Spirifera tullia Hall, 1867, p. 218, pl. 35, fig. 1-9.
Spirifer tullius Hall and Clarke, 1893, p. 14, 35, pl. 22, fig. 18, pl. 27, fig. 6, 7. — Grabau and Shimer, 1909, p. 332, fig. 422, e. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 195, pl. 19, fig. 1-7.

Shell of medium size, nearly equally biconvex, semicircular in outline; greatest width at, rarely anterior to, hinge; cardinal extremities form right angles, somewhat acuminate; surface plicate.

Pedicle valve very convex; length/width ratios average 0.71; beak extends about one-third of valve length behind hinge, moderately incurved, nearly normal in outline; cardinal slopes subparallel to hinge near cardinal angles; delthyrium triangular, as wide as high, open; sulcus well defined, shallow, broadly to regularly concave.

Brachial valve moderately convex; length/width ratios average 0.68; beak extends scarcely behind hinge; fold well defined, low, faintly furrowed, width at anterior margin about one-third of valve width.

Surface bears 8 to 11 rounded plications which are separated by narrow furrows; concentric growth varies few, widely spaced toward anterior margin; very fine, radiating striae on sulcus and on furrows between plicae; fine, concentric striae cross sulcus.

Interior of pedicle valve bears cardinal teeth; dental lamellae support teeth, thin, subparallel, extend about one-fourth of valve length; muscle areas poorly defined.

Interior of brachial valve with small, arrowhead-shaped muscle scars just anterior to beak; median septum thin, low, extends one-third of valve length.

Pedicle valve: length—8.5 to 17.5 mm; width—13 to 24 mm; convexity—2.5 to 7 mm.

Relationships.—"Spirifer" tullius is readily distinguished from all other spiriferids in this sequence by its relatively small size, its semicircular outline, and the fine radial striae that are conspicuous especially on the furrows between the plicae and on the sulcus. Internally, the moderately long, thin, subparallel dental lamellae that surround an unfilled delthyrial cavity are diagnostic. The absence of an apical callosity in the delthyrial cavity is an atypical feature for spiriferids in the Hamilton Group of south-central Pennsylvania. Species of *Spinocyrtia* and of *Mediospirifer* all have the delthyrial cavity partially filled by such a callosity.

Compared with Hall's description and illustrations of this species (1867, p. 218; pl. 35, fig. 1-9), specimens in this collection are somewhat less convex, have thinner and more delicate dental lamellae, and bear fewer plications, features they have in common with specimens of *"Spirifer" tullius* illustrated by Kindle and Prosser (1913, pl. 19, fig. 1-7).

Subfamily Ambocoeliinae

Genus Ambocoelia Hall

Ambocoelia umbonata (Conrad)

Pl. 13, fig. 19-21

Orthis umbonata Conrad, 1842, p. 264.

Ambocoelia umbonata Hall, 1860, p. 71. — Hall, 1867, p. 259, pl. 44, fig. 7-18. — Hall and Clarke, 1893, pl. 29, fig. 17; pl. 39, fig. 4-9. — Schuchert, 1897, p. 141. — Grabau and Shimer, 1909, p. 343, fig. 438, c, d. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 200, pl. 20, fig. 1, 2. — Cooper, in Shimer and Shrock, 1944, p. 329, pl. 126, fig. 21-26.

Shell small, plano-convex to biconvex, rostrate, subpentagonal in outline; greatest width just anterior to hinge line; lateral and anterior margins regularly rounded; cardinal extremities sharply rounded.

Pedicle valve gibbous; greatest convexity equals slightly less than one-half valve length; viewed anteriorly, valve is subcarinate in profile; length/width ratios average 1.04; beak prominent, incurved, extends one-fourth of valve length behind hinge; interarea high, arched, normal to obtuse on smaller forms, more obtuse on larger forms; prominent median sulcus extends from beak to anterior margin, becomes less distinct anteriorly.

Brachial valve nearly flat, apple-shaped in outline; greatest width near hinge.

Surface with fine, concentric striae number 2 per 1 mm near anterior margin; concentric growth varices more widely spaced than striae.

Interior of pedicle valve bears divergent cardinal teeth; small, elongate adjustor muscle scars; lateral and posterolateral margins slightly flattened, produce a peripheral flange.

Cardinalia of brachial valve includes bilobate cardinal process situated at apex of divergent crural lamellae; median septum; concentric growth varices visible internally.

Pedicle valve: length—4 to 14 mm; width—4 to 13 mm; convexity—1 to 6.5 mm.

Relationships.—This species is distinguished by its small size, sulcate pedicle valve, and the median septum on the brachial interior. Specimens of *Ambocoelia umbonata* collected from the Tully at Bedford, however, are somewhat larger than normal and have less prominent sulci; they, therefore, approach *Emmanuella* species in general aspect. Diagnostic features of four easily confused species are summarized in the accompanying table.

Species	*size*	*sulcus*	*spines*	*brachial septum*
Ambocoelia umbonata	small	present	absent	present
Echinocoelia ambocoeloides	small	absent	present	absent
Emmanuella pennsylvanica	large	absent	absent	absent
Emmanuella subumbona	small	absent	absent	absent

Genus Echinocoelia Cooper and Williams

Echinocoelia ambocoeloides Cooper and Williams

Pl. 13, fig. 22, 23

Echinocoelia ambocoeloides Cooper and Williams, 1935, p. 844, pl. 59, fig. 9, 13, 17, 21, 23. — Cooper, in Shimer and Shrock, 1944, p. 329, pl. 126, fig. 27-31.

Shell small, plano-convex, subpentagonal in outline; greatest width at hinge; surface spinose.

Pedicle valve moderately gibbous; greatest convexity equals 0.5 of valve length; length/width ratio for one specimen is 0.88; beak strongly incurved; sulcus narrow, becomes indistinct toward anterior margin.

Brachial valve nearly flat; length/width ratio for one specimen is 1.0; greatest width at hinge.

Surface bears closely and very evenly spaced concentric lamellae; small spines randomly disposed along lamellae.

Interior of brachial valve bears short crural lamellae; median septum low, extends almost to middle of valve.

Pedicle valve: length—7 mm; width—8 mm; convexity—3.5 mm.

Relationships.—This species is similar in most respects to *Ambocoelia umbonata,* and Cooper and Williams (1935, p. 844) suggest that *E. ambocoeloides* is, indeed, a form that evolved from that species. The spinose exterior, and the median septum of that brachial valve are two characteristics serving to distinguish *E. ambocoeloides* from *A. umbonata.* Otherwise, they are nearly identical, and easily confused.

Willard has found this species in the Tully throughout Pennsylvania, but it is always rare. Although the present investigation has not involved extensive collecting within the Tully, *Echinocoelia ambocoeloides* has been found in the Tully only at Huntingdon and Amity Hall, and in the Harrell shale at Amity Hall.

Family Spiriferinidae

Genus Cyrtina Davidson

Cyrtina hamiltonensis (Hall)

Pl. 13, fig. 24-26

Cyrtia hamiltonensis Hall, 1857, p. 166.

Cyrtina hamiltonensis Hall, 1867, p. 268, pl. 27, fig. 1-4; pl. 44, fig. 26-33, 38-52. — Hall and Clarke, 1893, pl. 28, fig. 23-33, 43, 45, 46, 53. — Schuchert, 1897, p. 198. — Grabau and Shimer, 1909, p. 313, fig. 393, a-c. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 185, pl. 17, fig. 1-9. — Cooper, in Shimer and Shrock, 1944, p. 359, pl. 140, fig. 37-39.

Shell medium in size, unequally biconvex, semipyramidal in form; greatest width at hinge; surface plicate.

Pedicle valve very gibbous; greatest convexity equals 0.59 of valve length, located 0.18 of valve length forward of beak; viewed anteriorly, valve is subcarinate; length/width ratios for 3 specimens average 0.66; beaks extend about one-fifth of valve length behind hinge; cardinal

slopes broadly concave; interarea one-third as high as width, regularly arched; sulcus one-third of valve width at anterior margin.

Brachial valve moderately convex; greatest convexity equals 0.30 of valve width; width of fold at anterior margin about one-third of valve width.

Surface bears 10 to 14 plicae; plicae rounded, number 1 per 1 mm at anterior margin.

Interior of pedicle valve bears narrow spondylium simplex; median septum thin, extends two-thirds of valve length; interior plicate; reflecting external ornament.

Pedicle valve: length—10 to 11 mm; width—15 to 18 mm; convexity—5.5 to 7 mm.

Relationships.—Cyrtina hamiltonensis is quite distinct from all other forms in the Hamilton Group of south-central Pennsylvania, primarily by virtue of its high, arched beak, and its spondylium with a long thin, supporting septum. This species differs from *C. alpenensis* and *C. umbonata*, two species from the Middle Devonian of mid-continental United States, in having less acute cardinal angles, and less strongly incurving beak.

Superfamily Rostrospiracea

Family Athyridae

Genus Athyris McCoy

Athyris spiriferoides (Eaton)

Pl. 13, fig. 27, 28

Terebratula spiriferoides Eaton, 1831, p. 137.

Atrypa concentrica Conrad, 1838, p. 111. — Hall, 1843, p. 198, fig. 5.

Spirifera spiriferoides Hall, 1857, p. 153, fig. 1, 2. — Rogers, 1858, p. 828, fig. 667.

Athyris spiriferoides Hall, 1860, p. 93, fig. 1-4. — Hall, 1867, p. 285, pl. 46, fig. 5-31. — Hall and Clarke, 1893, p. 89, fig. 60, 61; pl. 45, fig. 11-27. — Schuchert, 1897, p. 149. — Grabau and Shimer, 1909, p. 353, fig. 461. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 211, pl. 21, fig. 1, 2. — Cooper, in Shimer and Shrock, 1944, p. 333, pl. 127, fig. 39-43.

Shell medium to large in size, biconvex, transversely subpentagonal in outline; anterior margin subtruncate; lateral margins broadly rounded to nearly straight; cardinal angles sharply rounded; surface concentrically lamellose.

Pedicle valve very convex; greatest convexity equals 0.35 of valve

length; length/width ratios for 6 specimens average 0.81; sulcus shallow, weakly developed in anterior half of valve, width at anterior margin is one-fifth to one-fourth of valve width.

Brachial valve somewhat less convex than pedicle valve; greatest convexity equals 0.32 of valve length.

Surface bears fasciculate concentric lamellae which average 1 per 1 mm near anterior margin.

Pedicle valve: length—16.5 to 23 mm; width—20 to 29 mm; convexity—6 to 8 mm.

Relationships.—Athyris spiriferoides is distinguished from *A. cora* and *A. angelica* by its more sharply curved cardinal angles, and by the low fold and shallow sulcus which are evident only in the anterior half of the shell.

Phylum Mollusca

Class Pelecypoda

Order Prinodesmacea

Section A. Paleoconcha

Genus Phthonia Hall

Phthonia sectifrons (Conrad)

Pl. 14, fig. 1

Cypricardites sectifrons Conrad, 1842, p. 245, pl. 13, fig. 8.
Phthonia sectifrons Hall, 1885, p. 475, pl. 78, fig. 10-13. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 214, pl. 21, fig. 5-7. — Shimer and Shrock, 1944, p. 369, pl. 144, fig. 3.

Shell small, prosocline, elongate-elliptical in outline; valves depressed convex; anterior and posterior margins sharply rounded; ventral margin broadly rounded; cardinal line straight, extends to point less than one-third of shell length forward of posterior margin; length/width ratio 2.2; greatest length about mid-height in position.

Beak in anterior tenth of shell, not elevated above cardinal line.

Surface bears radiating lirae; lirae number about 8 per 1 mm near margins; concentric varices faint, few, irregularly spaced; umbonal ridge poorly defined.

Measurements: length—10 mm; height—4.5 mm; convexity—1 mm.

Relationships.—This species is distinguished by its elongate outline, fine concentric and radial striae, with stronger striae on umbonal elevation and anterior end. Measurements of specimens given by Hall (1885, p. 475), and by Prosser and Kindle (1913, p. 215) are considerably larger than those for specimens in this collection.

Genus Protomya Hall

cf. Protomya oblonga (Hall)

Pl. 14, fig. 2

Cardiomorpha oblonga Hall, 1883, pl. 63, fig. 21.
Protomya oblonga Hall, 1885, p. 509, pl. 63, fig. 21.

Shell large, prosocline, subelliptical in outline; valves moderately convex; ventral margin broadly rounded to nearly straight; posterior margin sharply rounded; cardinal line straight behind beak; length/height ratio about 2; greatest length about mid-height in position.

Beak located less than one-third of shell length behind anterior margin, prominent, elevated above hinge.

Surface bears fine concentric striae and widely spaced concentric plications.

Relationships.—Protomya oblonga is characterized by its large size, elongate outline, and concentric ornament of fine striae and coarse undulations. One incomplete valve in this collection is comparable to that species.

Genus Orthonota Conrad

Orthonota undulata Conrad

Pl. 14, fig. 3

Orthonota undulata Conrad, 1841, p. 51, fig. 6. — Rogers, 1858, p. 827, fig. 661. — Hall, 1885, p. 478, pl. 78, fig. 37-42. — Grabau and Shimer, 1909, p. 378, fig. 480. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 216, pl. 21, fig. 11-13. — Shimer and Shrock, 1944, p. 369, pl. 144, fig. 9, 10.

Shell medium-sized, prosocline, elongate-rhomboidal in outline; valves depressed convex; ventral margin nearly straight, subparallel with dorsal margin; posterior margin regularly rounded.

Beak located less than one-fourth of valve length behind anterior margin, prominent, slightly elevated above cardinal line; ligamental area narrow, extends from beak to posterior margin.

Surface bears fine concentric striae and coarse plications; plicae number 5 per 2 mm near beak and 2 per 2 mm near margins; ornament commonly obsolescent forward of umbonal carina and furrow which extend from beak to posterior margin.

Measurements: length—24 mm; height—10 to 13 mm; convexity—2 to 2.5 mm.

Relationships.—*Orthonota undulata* is easily recognized by its elongate outline with nearly parallel dorsal and ventral margins, as well as by its umbonal ridge and furrow, and the conspicuous undulations of the anterior margin and cardinal slope.

Orthonota? parvula Hall

Pl. 14, fig. 4, 5

Orthonota parvula Hall, 1870, p. 88.
Orthonota? parvula Hall, 1885, p. 482, pl. 65, fig. 2, 3; pl. 78, fig. 29-32. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 217, pl. 22, fig. 1, 2.

Shell small, prosocline, produced subrhomboidal in outline; anterior margin sharply rounded; ventral margin nearly straight, about parallel with dorsal margin; postero-ventral margin sharply curving onto broadly rounded posterior margin; posterior margin meets cardinal line at angle of from 140 to 150 degrees; length/height ratio from 2.5 to 3.5.

Beak less than one-fourth of valve length behind anterior margin, appressed, elevated slightly above cardinal line; carina weli defined, extends from beak to postero-ventral margin; ligamental area narrow, extends along dorsal margin behind beak.

Surface bears fine, unevenly spaced concentric plications.

Measurements: length—7.5 to 10 mm; height—2.5 to 3 mm; convexity—less than 1 mm.

Relationships.—Hall (1885) placed this species in the genus *Orthonota* because of its long, straight hinge line, the absence of a lunule, and the apparent absence of an external ligament. Its surface marking is like that of *Orthonota carinata*. Specimens of *O. parvula* in this collection have the diagnostic elongate, trapezoidal form, the nearly straight dorsal and ventral margins, and the angular umbonal ridge with a slightly concave cardinal slope.

Genus Grammysia Verneuil

Grammysia arcuata (Conrad)

Pl. 14, fig. 6, 7

Posidonia? arcuata Conrad, 1841, p. 53.
Grammysia arcuata Hall, 1883, pl. 63, fig. 6.
Grammysia arcuata Hall, 1885, p. 373, pl. 61, fig. 1-9; pl. 63, fig. 6; pl. 92, fig. 27. — Grabau and Shimer, 1909, p. 383, fig. 484, e, f. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 219, pl. 22, fig. 4-10. — Shimer and Shrock, 1944, p. 371, pl. 144, fig. 26, 27.

Shell medium to large in size, prosocline, ovate in outline; valves very convex; anterior margin regularly rounded; ventral margin broadly rounded; posterior margin regularly rounded; cardinal line nearly straight; length/height ratio 1.5.

Beak elevated slightly above hinge, incurved, situated less than one-fourth of valve length behind anterior margin.

Surface bears concentric rugae; rugae spaced 6 per 2 mm on beak, spaced 1 per 2 mm near margins, increase by implantation in posterior two-thirds of valve.

Lunule distinct; escutcheon defined by longitudinal furrow running just below cardinal line.

Measurements: length—33 mm; height—22 mm; convexity—10 mm.

Relationships.—*Grammysia arcuata* differs from *Grammysioides alveata* in its more elongate form, more rounded posterior end, somewhat constricted ventral margin, and uninterrupted concentric rugae that continue across umbonal slope.

Genus Grammysioidea Williams and Breger

Grammysioidea alveata (Conrad)

Pl. 14, fig. 8

Posidonia alveata Conrad, 1841, p. 53.

Grammysia alveata Hall, 1870, p. 55. — Hall, 1885, p. 370, pl. 57, fig. 1, 2; pl. 60, fig. 1-11. — Grabau and Shimer, 1909, p. 381, fig. 487.

Grammysioidea alveata Shimer and Shrock, 1944, p. 371, pl. 144, fig. 21, 22.

Shell medium to large in size, gibbous; length/height ratio about 1; beaks nearly erect, spirogyral.

Surface bears concentric rugae spaced about 1 per 3 mm.

Relationships.—This species is more erect and more gibbous, and has more erect beaks than *Grammysia arcuata*. Otherwise the two species are very similar.

Genus Tellinopsis Hall

Tellinopsis subemarginata (Conrad)

Pl. 14, fig. 9, 10

Nuculites subemarginata Conrad, 1842, p. 249, pl. 15, fig. 5.

Tellinopsis subemarginata Hall, 1885, p. 464, pl. 76, fig. 21-31. — Grabau and Shimer, 1909, p. 386, fig. 488, d. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 222, pl. 22, fig. 11, 12. — Shimer and Shrock, 1944, p. 371, pl. 145, fig. 11.

Shell of medium size, prosocline, subequilateral, subrectangular in outline; valves depressed convex; anterior margin regularly rounded; ventral margin broadly rounded; posterior margin emarginate; cardinal line nearly length of shell, anterior to as well as behind beak, subtends an angle greater than 135°; length/height ratios average 1.65.

Beaks just forward of middle of shell, appressed, elevated scarcely above hinge; two umbonal ridges depressed, extend to lower half of posterior margin.

Surface bears fine concentric striae, 4 per 1 mm near margin of larger specimen; about every fifth furrow assumes prominence at posterior, producing more coarsely striate ornament; radiating lirae fine, widely spaced, on posterior half of shell.

Measurements: length—12 to 30.5 mm; height—7 to 18.5 mm; convexity—1 to 2 mm.

Relationships.—This species is easily recognized by its subrectangular outline and the central position of its beaks, as well as by its surface ornament, consisting of concentric lamellae and radiating lirae that are especially prominent on the posterior half of the shell. No similar species are found in the Hamilton Group of New York nor in Pennsylvania. Specimens collected in Pennsylvania are similar in size and proportions with those described by Kindle and Prosser in Maryland (1913, p. 223).

Section B. Taxodonta

Superfamily Nuculacea

Genus Nucula Lamarck

Nucula lirata (Conrad)

Pl. 14, fig. 11

Nuculites lirata Conrad, 1842, p. 250, pl. 15, fig. 7.

Nucula lirata Hall, 1870, p. 3 — Hall, 1885, p. 316, pl. 45, fig. 5, 11, 15, 17-22, 24, 25; pl. 93, fig. 5. — Grabau and Shimer, 1909, p. 395, fig. 503, d. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 229, pl. 25, fig. 6-8, 9?, 10?.

Nucula (Nuculoidea) lirata Shimer and Shrock, 1944, p. 375, pl. 115, fig. 12.

Surface bears concentric terrace-like growth varices across which fine lirae radiate.

Relationships.—The species is represented in this collection by a fragmental external cast. *Nucula lirata* is distinguished from all other species of *Nucula* by its distinctive ornament consisting of prominent concentric undulations crossed by numerous radiating lirae.

Nucula bellistriata (Conrad)

Pl. 14, fig. 12, 13

Nuculites bellistriata Conrad, 1841, p. 40.
Nucula bellistriata Hall, 1885, p. 318, pl. 46, fig. 1-9. — Grabau and Shimer, 1909, p. 395, fig. 503, e. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 227; pl. 25, fig. 1-5. — Shimer and Shrock, 1944, p. 375, pl. 145, fig. 23.

Shell small to medium in size, prosocline, inequilateral, subovate to suborbicular in outline; valves depressed convex; length slightly greater than height; posterior and ventral margins broadly rounded; anterior margin more sharply rounded below; cardinal line arcuate, obtuse; greatest convexity located near middle of shell.

Beak located less than one-fourth of shell length behind anterior margin, prosogyral, slightly appressed, extending slightly above cardinal margin.

Surface bears uniformly close-spaced, regular, subangular, concentric striae; striae not fasciculate, about 4 per 1 mm at margins, 8 to 9 per 1 mm near beak; growth lines present on larger specimens.

Measurements: length—4 to 16 mm; height—3.5 to 15.5 mm.

Relationships.—The distinguishing features of this species are its broad, suborbicular outline, and uniformly spaced, regular, concentric striae. *N. bellistriata* is less convex than *N. randalli,* and also has more regular striae and more appressed beaks. Hall (1885, p. 318) notes that some phases of this species resemble *N. varicosa;* this is true also for some specimens in the present collection from south-central Pennsylvania. Growth varices as shown by a few of Hall's specimens (1885, pl. 46, fig. 2 and 6) are present in some degree on all specimens in this collection, but differentiating this species from *N. varicosa* is not difficult because that species lacks the uniformly regular concentric striae. Specimens of *N. bellistriata* from Pennsylvania generally are noticeably smaller and relatively shorter than those from New York.

Nucula varicosa Hall

Pl. 14, fig. 14, 15

Nucula varicosa Hall, 1870, p. 2. — Hall, 1885, p. 319, pl. 46, fig. 12-23; pl. 93, fig. 4. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 230, pl. 25, fig. 11-16.

Shell medium-sized, prosocline, subcircular in outline; valves depressed convex; margins regularly rounded except for upper part of

anterior margin which is slightly produced; length/height ratios for 3 specimens average 1.12.

Beak located about one-fourth or less than one-fourth of valve length behind anterior margin, elevated above hinge.

Surface bears faint, concentric striae; growth varices prominent, spaced 1 per 4 mm near beak, spaced 3 per 1 mm near margins.

Measurements: length—16 to 17 mm; height—13 to 16 mm; convexity—2.5 to 3.5 mm.

Relationships.—This species is most easily confused with *N. bellistriata*, but the shell is more erect, the beaks are more elevated, and the outline is more triangular. In addition, the numerous growth varices with only faint concentric striae are typical of *N. varicosa*. Specimens from Maryland and Pennsylvania compare favorably in size with measurements provided by Hall (1885, p. 319) for several specimens taken from the Hamilton Group in New York.

Genus Nuculites Conrad

Nuculites oblongatus (Conrad)

Pl. 14, fig. 16-20

Nuculites oblongata Conrad, 1841, p. 50, pl., fig. 8.
Nucula? oblonga Hall, 1843, p. 196.
Nuculites oblongatus Hall, 1885, p. 324, pl. 47, fig. 1-12. — Grabau and Shimer, 1909, p. 398, fig. 509, a-c. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 231, pl. 25, fig. 17-20. — Shimer and Shrock, 1944, p. 377, pl. 146, fig. 13, 14.

Shell medium in size, prosocline, inequilateral, elongate-elliptical in outline; valves depressed convex; anterior margin sharply to regularly rounded; ventral margin broadly rounded; posterior margin bluntly rounded; cardinal line arcuate; length/height ratio about 2; greatest length about mid-height in position.

Beaks less than one-third of valve length behind anterior margin, appressed, not elevated above hinge.

Surface smooth or with very faint concentric growth varices.

Interior of shell bears taxodont hinge line with teeth extending about two-thirds of shell length on either side of beak; clavicle nearly vertical, extends from beak to lower one-third of valve.

Measurements: length—7.5 to 21 mm; height—4 to 10.5 mm; convexity—0.5 to 1.5 mm.

Relationships.—*Nuculites oblongatus* is one of the most easily recognized and most commonly found pelecypod species in the Mahantango

Formation. Generally, it can be recognized by its elongate outline, depressed convexity, and by its anterior clavicle. Although similar to *N. cuneformis,* it has a shorter anterior end, wider post-cardinal slope, and umbonal ridge.

Two somewhat different forms of this species are recognized in the Mahantango Formation in south-central Pennsylvania: one form is more or less typical of *Nuculites oblongatus* Hall, and the second is larger, more elongate in outline, and has a narrower posterior end. As these two forms are stratigraphically separated, except at the base of the upper shale member at Girtys Notch, they may be valid species or subspecies. Prosser and Kindle (1913, p. 232) also note the wide range in form shown by this species. Until further study of these forms is made, however, both forms have been referred to *Nuculites oblongatus.*

Nuculites triqueter Conrad

Pl. 14, fig. 21-23

Nuculites triqueter Conrad, 1841, p. 50. — Hall, 1885, p. 326, pl. 47, fig. 17-28; pl. 93, fig. 8-10. — Grabau and Shimer, 1909, p. 398, fig. 509, d-f. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 232, pl. 26, fig. 1-5. — Shimer and Shrock, 1944, p. 377, pl. 146, fig. 15, 16.

Shell medium in size, prosocline, rhomboidal to trigonal in outline; valves depressed convex to very convex; anterior margin broadly to regularly rounded; ventral margin broadly rounded to nearly straight; posterior margin sharply rounded around point of greatest length, nearly straight up to cardinal line; greatest length located in ventral third of shell; cardinal line arcuate; length/height ratio about 1.3; umbonal ridge.

Beak located about one-third of shell length behind anterior margin, elevated slightly above hinge.

Surface bears fine concentric striae in umbonal region, crowded and finer concentric striae in anterior portion and on umbonal slope.

Interior bears taxodont dentition; teeth extend somewhat less than two-thirds of shell length in front of and behind beak; clavicle bounds umbo anteriorly, sharply defined, thin, extends vertically to ventral third of shell.

Measurements: length—7 to 15 mm; height—6.5 to 14 mm; convexity—1 to 3 mm.

Relationships.—This species is represented by several internal molds. Its trigonal form is like that of *Nucula varicosa,* but it differs from that species in being larger, having a more angular umbonal slope, having

a smooth surface, and in possessing the distinctive clavicle. Hall (1885, p. 327) notes a wide variation in size and specific characteristics for this species.

Although somewhat smaller, the specimens in this collection are very much like those illustrated by Hall (1885, pl. 47, fig. 17-28). Measurements and proportions of specimens in this collection are comparable to those of specimens from Maryland and New York.

Genus Palaeoneilo Hall

Palaeoneilo muta Hall

Pl. 14, fig. 24

Palaeoneilo muta Hall, 1870, p. 8. — Hall, 1885, p. 337, pl. 49, fig. 25-32. — Grabau and Shimer, 1909, p. 398, fig. 510, g-i. — Shimer and Shrock, 1944, p. 377, pl. 146, fig. 22.

Shell large, convex, prosocline, elongate-ovoid outline; anterior margin regularly rounded; posterior margin doubly truncate; cardinal line slightly arcuate behind beak, extends one-half distance in front of beak to position of greatest length; greatest length of shell above middle of shell; greatest convexity near middle of shell; length/height ratio approximately 2.

Beak scarcely above cardinal line, just forward of mid-length in position.

Surface bears concentric lamellae; lamellae uniformly spaced 3 to 4 per 2 mm over most of shell, more crowded at anterior and posterior margin.

Measurements: length—38 mm; height—20 mm; convexity—5 mm.

Relationships.—This species is similar to *Palaeoneilo fecunda,* differing chiefly in having the entire shell covered by strong, concentric lamellose striae, whereas in *P. fecunda* the striae are restricted to the posterior half of the shell. The ornament differentiates *P. muta* from *P. tenuistriata* and *P. perplana. Palaeoneilo tenuistriata* has finer and less regular concentric ornament than *P. muta,* and *P. perplana* has concentric lamellae that are obsolete anteriorly and on the umbonal ridge. Specimens from Pennsylvania in this collection compare well with those from New York, in size, outline, and ornament.

Palaeoneilo emarginata (Conrad)

Pl. 14, fig. 25, 26

Nuculites emarginata Conrad, 1841, p. 50.

Palaeoneilo emarginata Hall, 1870, p. 7. — Hall, 1885, p. 338, pl. 50, fig. 1-11. — Grabau and Shimer, 1909, p. 400, fig. 510, m-p. — Prosser

and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 241, pl. 27, fig. 1-6. — Shimer and Shrock, 1944, p. 377, pl. 146, fig. 24.

Shell medium-sized, prosocline, subelliptical in outline; anterior margin regularly rounded; valves depressed convex; ventral margin nearly straight; postero-ventral margin emarginate, producing nasute posterior; cardinal line straight, posterior to beak; length/height ratios average 1.7; greatest convexity near middle of shell; umbonal carina extends from beak to postero-ventral margin, subtends angle of 25° with cardinal line.

Surface bears concentric lamellae; lamellae distantly spaced, number 1 to 2 per 1 mm, with fine concentric striae between adjacent lamellae.

Measurements: length—5 to 26 mm; height—2.5 to 16 mm; convexity—0.5 to 3 mm.

Relationships.—The deeply emarginate postero-ventral margin and the strong, evenly and widely spaced concentric lamellae are diagnostic features of *P. emarginata.*

Specimens of this species in the present collection, and measurements of specimens from Maryland, given by Prosser and Kindle (1913, p. 242), are nearly all smaller than those from New York, as indicated by Hall's measurements and illustrations of this species (1885, p. 338; pl. 50, fig. 1-11).

Palaeoneilo constricta (Conrad)

Pl. 14, fig. 27-37

Nuculites constricta Conrad, 1842, p. 249, pl. 15, fig. 8.
Nucula bellatula Hall, 1843, p. 197, fig. 7, on p. 196.
Palaeoneilo constricta Hall, 1870, p. 7. — Hall, 1885, p. 333, pl. 48, fig. 1-16; pl. 51, fig. 17. — Grabau and Shimer, 1909, p. 400, fig. 510, a, b. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 235, pl. 26, fig. 9-12. — Shimer and Shrock, 1944, p. 377, pl. 146, fig. 20, 21.

Shell medium in size, prosocline, inequilateral, elliptical to subovate in outline; anterior margin regularly rounded; ventral margin broadly rounded anteriorly, slightly constricted or concave posteriorly; posterior margin sharply rounded, somewhat nasute; cardinal line arcuate, extends nearly length of shell behind beak, extends one-half distance forward of beak; length/height ratios average 1.5.

Surface bears concentric striae; striae fine, uniformly spaced, number about 8 per 1 mm near margins, number 10 per 1 mm near beak.

Interior bears taxodont hinge with numerous fine teeth anterior to and posterior to beaks.

Measurements: length—9 to 19 mm; height—5 to 15 mm; convexity—1 to 2 mm.

Relationships.—This species is recognized by its fine, uniformly and closely spaced concentric striae, its constricted postero-ventral margin, and its subnasute posterior extremity. Although similar in size and ornament with *Nucula bellistriata,* it differs from that species in outline, and in the constricted basal margin, and in the erect beak. *Palaeoneilo constricta* is proportionately higher than *P. perplana,* and more constricted than *P. maxima.*

Specimens of this species described by Hall (1885, p. 333) range in length from 16 to 25 mm, and range in height from 12 to 18 mm. Maryland specimens, as described by Prosser and Kindle (1913, p. 236) range in length from 13 to 17 mm, and range in height from 9 to 11 mm. Specimens of *P. constricta* from south-central Pennsylvania range in length from 9 to 18 mm, and range in height from 5 to 15 mm.

Palaeoneilo plana Hall

Pl. 15, fig. 1, 2

Palaeoneilo plana Hall, 1870, p. 7. — Hall, 1885, p. 334, pl. 48, fig. 21-28. — Grabau and Shimer, 1909, p. 399, fig. 510, f. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 237, pl. 26, fig. 13-15.

Shell medium in size, elongate-elliptical in outline; anterior margin sharply rounded; posterior margin sharply rounded and slightly produced; ventral margin broadly rounded; cardinal line arcuate; length/height ratio greater than 2; position of greatest width above mid-line.

Beaks appressed, extending slightly above cardinal line, located between one-third and one-half of valve length behind anterior margin.

Surface bears irregularly spaced, very fine concentric striae.

Measurements: length—16 to 18 mm; height—8 mm; convexity— 1 to 2 mm.

Relationships.—This species is distinguished from *P. constricta* by its more elongate outline, more nearly central beaks, and the absence of a constriction along the postero-ventral margin. The nearly smooth surface, with only faint, fine, concentric striae also is distinctive. Average lengths of specimens from New York, Maryland, and Pennsylvania are approximately the same.

Palaeoneilo tenuistriata Hall

Pl. 15, fig. 3

Palaeoneilo tenuistriata Hall, 1870, p. 9. — Hall, 1885, p. 336, pl. 49, fig. 1-12; pl. 93, fig. 13. — Grabau and Shimer, 1909, p. 399, fig. 510, c. —? Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 242, pl. 27, fig. 7.

Shell medium-sized, subelliptical in outline; posterior margin doubly truncate; valves depressed convex; anterior margin regularly rounded; ventral margin broadly rounded; greatest convexity located near middle of shell; greatest length located somewhat above mid-line of shell; umbonal slope nearly flat to slightly concave; length/height ratio 2.7 for one specimen.

Beaks appressed, located one-third of shell length behind anterior margin.

Surface bears concentric striae; striae fine, irregularly crowded, number 4 to 5 per 1 mm on umbonal slope, nearly obsolete on anterior half of shell.

Interior with arcuate taxodont hinge; one-third of hinge line forward of beak; two-thirds of hinge line posterior of beak.

Measurements: length—25 mm; height—15 mm; convexity—2.5 mm.

Relationships.—This species is distinguished from *Palaeoneilo fecunda* by its finer and less regularly concentric striae, and by its somewhat less elongate form. The outline and size of *P. tenuistriata,* however, varies considerably between specimens from New York, Maryland, and Pennsylvania.

Palaeoneilo perplana Hall

Pl. 15, fig. 4, 5

Palaeoneilo? perplana Hall, 1870, p. 12. — Hall, 1885, p. 339, pl. 50, fig. 15-22; pl. 93, fig. 12.

Shell large, elongate-ovate in outline; anterior margin regularly to sharply rounded; valves depressed convex; ventral margin broadly rounded toward doubly truncate posterior margin; posterior margin nasute; greatest length located about mid-height, well below posterior end of cardinal line; umbonal ridge well defined, extends from beak to posterior margin.

Surface bears concentric lamellae; lamellae distantly spaced, distinct in posterior half except on umbonal ridge, but nearly obsolete in anterior half of shell.

Relationships.—Three fragments of molds of this species have been collected, one of which is an almost complete right valve. Consequently, measurements and certain morphologic details have not been observed.

Palaeoneilo perplana resembles *P. fecunda* and *P. muta,* but the umbonal ridge is less well defined, the posterior extremity is more extended, and the lamellae are more distinctly spaced in this species.

The relative flatness of specimens in this collection may be due, in part, to deformation; this possibility has been entertained by Hall (1885, p. 339) for his flattened specimens of this species which were found in the shalier portions of the Hamilton Group in New York.

Palaeoneilo filosa (Conrad)?

Pl. 15, fig. 6

Nuculites filosa Conrad, 1842, p. 250, pl. 15, fig. 7.
Palaeoneilo filosa Hall, 1870, p. 10. — Hall, 1885, p. 343, pl. 49, fig. 33-38. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 623, pl. 56, fig. 11, 12.

Shell medium in size, subrhomboidal in outline; anterior margin regularly rounded; valves depressed convex to nearly flat; ventral margin nearly straight; posterior margin truncate; postero-ventral margin straight; cardinal line arcuate, extends to position just slightly above position of greatest length; greatest length located about one-fourth of shell height below beak.

Beak appressed, located one-third of shell length behind anterior margin.

Surface bears faint concentric striae on anterior and medial portions of shell; concentric lamellae uniformly spaced, about 5 per 1 mm, on posterior portion of shell, with fine striae between lamellae.

Interior bears taxodont hinge extending from beak posteriorly almost to position of greatest length.

Measurements: length—16 mm; height—11 mm; convexity—1.5 mm.

Relationships.—According to Hall (1885, p. 343), *Palaeoneilo filosa* can be differentiated from *P. fecunda,* also of the Hamilton Group, on the basis of the posterior extremity, which is extended at the cardinal line of this species. Furthermore, *P. filosa* is about one-half as long as *P. fecunda;* length measurements of specimens illustrated by Hall range from 23.5 to 30 mm.

One specimen from the Mahantango Formation is tentatively referred to this species, on the basis of the cardinal line that extends almost to the position of greatest length, and the surface ornament which is most like that of *P. filosa* and *P. fecunda.* This specimen, however, is smaller, relatively shorter, and less convex than any specimens of this species illustrated or described by Hall.

Palaeoneilo fecunda Hall

Pl. 15, fig. 7

Palaeoneilo fecunda Hall, 1870, p. 8. — Hall, 1885, p. 336, pl. 49, fig. 13, 15-24. —Grabau and Shimer, 1909, p. 399, fig. 510, k, l. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 239, pl. 26, fig. 18-21. — Shimer and Shrock, 1944, p. 377, pl. 146, fig. 23.

Shell of medium size, elongate-elliptical in outline; valves depressed convex; posterior extremity truncate; anterior margin regularly rounded; ventral margin broadly rounded; cardinal slope nearly flat to slightly concave.

Beak located less than one-fourth of valve length behind anterior margin.

Surface bears concentric striae; striae closely spaced, nearly obsolete forward of poorly defined umbonal ridge, appear as well defined, widely spaced lamellae on cardinal slope.

The single specimen of this species measures 25.5 mm in length, 13.5 mm in height, and 3 mm in convexity of one valve.

Relationships.—This species is represented by one nearly complete internal mold of a left valve and two fragments. *Palaeoneilo fecunda* is like *P. muta* and *P. tenuistriata,* but the striae on the anterior part of the shell of this species are fine, and the concentric ornament on the posterior part of the shell consists of well defined lamellae. In contrast, *Palaeoneilo muta* has lamellae across the entire surface of the valve, and *P. tenuistriata* has fine striae on cardinal slope. The more or less complete specimen in this collection is nearly the same size as the specimen from Maryland for which Prosser and Kindle (1913, p. 240) give measurements. However, the specimen is considerably smaller than any from New York for which Hall gives measurements. Hall's specimens range in length from 35 to 43 mm.

Genus Nuculana Link

Nuculana diversa (Hall)

Pl. 15, fig. 8

Leda (Nuculana) diversa Hall, 1884, pl. 47, fig. 31-37.

Leda diversa Hall, 1885, p. 329, pl. 47, fig. 31-37. — Grabau and Shimer, 1909, p. 401, fig. 511, c. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 247, pl. 28, fig. 3, 4.

Nuculana diversa Shimer and Shrock, 1944, p. 377, pl. 146, fig. 34.

Shell small to medium in size, inequilateral, prosocline, transversely lunate to subfalcate in outline; posterior extremity very sharply

rounded, forms extremely nasute extension; umbonal slope gently concave; length/height ratios average 1.7 for two specimens.

Beak located between one-third and one-half of valve length behind anterior margin, strongly incurved.

Surface bears fine, uniformly spaced concentric striae and widely spaced growth varices near margin.

Measurements: length—9 to 20 mm; height—5.5 to 11 mm.

Relationships.—*Nuculana diversa* differs from *N. rostellata* in having a shorter and less curved posterior end, a broader and more extended anterior end, and beaks farther from the anterior margin.

Superfamily Arcacea

Genus Parallelodon Meek

Parallelodon hamiltoniae (Hall)

Pl. 15, fig. 9

Macrodon hamiltoniae Hall, 1870, p. 13. — Hall, 1885, p. 349, pl. 51, fig. 1-7, 9, 10.

Parallelodon hamiltoniae Grabau and Shimer, 1909, p. 403, fig. 517, b, c. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 248, pl. 28, fig. 8-12. — Shimer and Shrock, 1944, p. 379, pl. 146, fig. 44.

Shell medium in size, prosocline, elongate-ovoid in outline; valves depressed convex to nearly flat in profile; anterior margin sharply to regularly rounded; ventral margin broadly rounded; posterior margin regularly rounded; cardinal line straight; greatest length located about one-half of valve height below dorsal margin; length/height ratios average 2.25.

Beak about one-third of valve length behind anterior margin, elevated somewhat above hinge line.

Surface bears widely spaced concentric lamellae; faint concentric striae between lamellae; radiating lirae fine, on posterior half of shell.

Escutcheon bears two longitudinal ridges and two furrows subparallel to cardinal line.

Measurements: length—30 mm; height—15 mm; convexity—4 mm.

Relationships.—Three specimens of this species have been collected from the Mahantango in south-central Pennsylvania. *Parallelodon hamiltoniae* is readily recognized by its distantly spaced concentric lamellae with fine radiating lirae. These features, as well as the posterior end which is higher than the anterior end, the absence of a constriction along the ventral margin, and the more ovate outline distinguish this species from *P. chemungensis.* Both species exhibit an escutcheon with

a pair of longitudinal ridges and furrows that is so characteristic of this genus.

Although not all of the specimens in this collection are complete enough to permit measurements, they appear to be of similar size as specimens from New York, measurements of which are given by Hall (1885, p. 350).

Section C. Schizodonta

Superfamily Pteriacea

Genus Cornellites Williams

Cornellites flabella (Conrad)

Pl. 15, fig. 10, 11

Avicula flabella Conrad, 1842, p. 238, pl. 12, fig. 8. — Rogers, 1858, p. 827, fig. 659.

Pterinea flabella Hall, 1885, p. 93, pl. 14, fig. 1-21; pl. 15, fig. 1, 4-6, 8-10; pl. 83, fig. 11, 12.

Pterinea (Cornellites) flabellum Grabau and Shimer, 1909, p. 421, fig. 551.

Pterinea flabellum Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 250, pl. 29, fig. 1-4.

Cornellites flabella Shimer and Shrock, 1944, p. 383, pl. 148, fig. 18.

Shell large, prosocline, obliquely subtrigonal in outline, alate; posterior margin of wing nearly straight to broadly concave; postero-dorsal margin of shell body nearly straight, extends obliquely to beak, subtends angle of from 30 to 45 degrees with hinge line; length/height ratios average 1.2.

Beak less than one-fourth of valve length behind anterior margin, elevated slightly above hinge line.

Ear generally small, maximum extension about one-fourth of valve length, with byssal sinus paralleling anterior margin of shell body and slightly less than one-half of length of ear, height less than one-half shell height, with sinuate ventral margin.

Wing flattened to slightly convex, extends nearly to point above posterior extremity of shell body.

Surface of left valve bears 5 to 9 primary radial plicae; secondary costae number 5 to 9, indistinct on some specimens between primary plicae, most prominent between four most posterior plicae; tertiary costae number 10 to 20; costae more uniform on wing, number 1 or 2 on ear; concentric growth lines faint on internal molds, appear as closely spaced lamellae on external molds, conspicuous on ear and wing; growth varices rare.

Surface of right valve smooth except for concentric growth lines toward margins.

Measurements: length—26 to 50 mm; height—20 to 50 mm; convexity—5 to 11 mm.

Relationships.—One of the more widely distributed species, *Cornellites flabella* is represented in this collection by numerous specimens, many of which are nearly entire impressions. The surface ornament of the left valve is unlike that of any other associated form, consisting of several strong radiating plicae, between which are intermediate costae. The right valve lacks this distinctive ornament and is, therefore, easily confused with *Cornellites chemungensis* or *Actinopteria boydi.*

Specimens of this species in this collection show considerable range in characteristics.

Measurements of shell lengths given by Hall (1885, p. 95) range from 15 to 46 mm, as compared with those of specimens in this collection which range from 26 to 50 mm. The length of one specimen from the "Hamilton Member" of the "Romney Formation" in Maryland, as given by Prosser and Kindle (1913, p. 250), is 37 mm. The specimens of *Cornellites flabella* from these three areas are quite similar in size, but are somewhat larger in Pennsylvania.

Genus Leiopteria Hall

Leiopteria laevis (Hall)

Pl. 15, fig. 12

Avicula laevis Hall, 1843, p. 181. — Rogers, 1858, p. 827, fig. 662.
Pteronites? laevis Hall, 1859, p. 89. — Miller, 1877, p. 202.
Leiopteria laevis Hall, 1885, p. 158, pl. 17, fig. 5-11. — Grabau and Shimer, 1909, p. 424, fig. 555, a, b. — Kindle, 1912, p. 253, pl. 29, fig. 6. — Shimer and Shrock, 1944, p. 385, pl. 149, fig. 2, 3.

Shell small, acline to prosocline, pterinoid in outline; ventral margin curving upward and inward rather abruptly onto posterior margin of wing; cardinal line nearly straight; length about equal to height.

Beak at or anterior to middle of shell, elevated above hinge line, nearly erect or prosogyral.

Ear nearly one-third of shell length, slightly depressed below hinge line dorsally, with fold separated from shell body by well-defined sulcus.

Wing larger than anterior ear, nearly flat, extended slightly along hinge line, with concave posterior margin.

Surface bears concentric striae; striae fine and closely spaced in umbonal region, become coarser, more widely, and less regularly spaced toward margins, present on ear and wing.

Measurements: length—10 to 13 mm; height—10 to 12 mm.

Relationships.—*Leiopteria laevis* is characterized by its small size, the prominent anterior ear with an oblique fold and sulcus, the beak situated at or just anterior to the middle of the shell, and the posterior wing with a concave posterior margin and extension along the hinge.

Specimens of this species from south-central Pennsylvania are nearly of the same size as those from New York, measurements of which are given by Hall (1885, p. 158).

Further discussion of the relationships of this species with other species of *Leiopteria* is given in the discussion of the following "*Leiopteria* sp.".

Leiopteria sp.

Pl. 15, fig. 13-16

Shell medium in size, acline to slightly prosocline, pterinoid in outline; valves moderately convex; postero-dorsal margin converges with anterior margin at beak to form angle of less than 45°.

Beak scarcely elevated above hinge line, located just behind anterior margin.

Ear short, slightly sulcate.

Wing near flat, with vertical to somewhat concave posterior margin.

Surface bears fine, sharp concentric lamellae; lamellae distantly spaced, crowded on anterior ear, absent on wing.

Measurements: length—17 to 19 mm; height—17.5 to 18.5 mm; convexity—2.0 to 4.5 mm.

Relationships.—Several specimens of *Leiopteria* have been collected which are not readily referred to species of that genus as described by Hall. Indeed, these specimens may represent more than one species. Upon study of Hall's descriptions and illustrations of *Leiopteria* species, it is apparent that many of the species are practically indistinguishable from one another and may, in fact, represent variants of a much smaller number of species than described by Hall. In an effort to analyze Hall's species, three measurements were made of specimens of *Leiopteria* illustrated by Hall (1885, pl. 20 and 68); the greatest dimension of the shell was measured from the tip of the beak to the postero-ventral extremity; the posterior hinge length was measured from the beak to the posterior tip of the wing; and the obliquity was measured as the angle between the hinge line and the line of greatest dimension.

The posterior hinge length and the obliquity are two of the more important characteristics of these forms used in differentiating species of *Leiopteria,* according to Hall. Four groups of species are distinguishable on the basis of these two qualities.

1. *Leiopteria conradi* group including *L. rafinesquii, L. bigsbyi,* and

L. dekayi.—characterized by moderate posterior extension of the hinge, and more oblique attitude of the shell; surface ornament consists of somewhat fasciculate concentric lamellae; most variable of the four groups.

2. *Leiopteria greeni* group including *L. troosti, L. mitchelli,* and *L. oweni.*—characterized by greatest posterior extension of the hinge and intermediate obliquity of the shell; surface ornament consists of somewhat fasciculate concentric lamellae.
3. *Leiopteria sayi.*—characterized by very oblique specimens as in the *L. laevis* group; *L. sayi,* however, generally is more extended posteriorly than *L. laevis.*
4. *Leiopteria laevis* group including *L. laei.*—characterized by less extension of the hinge than all other groups, and ranging in obliquity from moderate—43 degrees—to maximum recorded for the genus—60 degrees. *Leiopteria gabbi* may be included in this group, but is quite different with regard to obliquity and hinge extension from all other species.

Genus Glyptodesma Hall

Glyptodesma erectum (Conrad)

Pl. 15, fig. 17, 18

Avicula cruciformis Conrad, 1841, p. 54.
Avicula erecta Conrad, 1842, p. 238, pl. 12, fig. 5.
Actinodesma erectum Miller, 1877, p. 180.
Glyptodesma erectum Hall, 1885, p. 153, pl. 11, fig. 1-10; pl. 12, fig. 1-3, 5-9; pl. 13, fig. 1-4, 12-15; pl. 25, fig. 14-17; pl. 86, fig. 1-8; pl. 87, fig. 1-3.
Actinodesma erectum Grabau and Shimer, 1909, p. 423, fig. 553, a, b.
Glyptodesma erectum Shimer and Shrock, 1944, p. 383, pl. 149, fig. 7, 8.

Shell large, prosocline, aviculoid in outline; anterior slope meets hinge at about 45°.

Beak between one-half and one-third of hinge length behind anterior margin, prominent, extends slightly above hinge line.

Ear somewhat less than one-third of hinge length, margin moderately sinuate, convex dorsally parallel to hinge, sulcate toward shell body.

Wing about three-fifths of valve length, nearly flat, margin broadly to regularly concave.

Surface bears fine concentric striae near margins of shell; striae fasciculate on anterior ear.

Interior bears two strong lateral teeth behind beak.

Relationships.—This is an abundant species in New York, but only two specimens are represented in this collection. *Glyptodesma erectum*

can be recognized by its large size and more or less erect form. Hall (1885, p. 154) indicates that this species exhibits considerable variation in the wing development, the obliquity of the valves, and the number of lateral teeth.

Genus Leptodesma Hall

Leptodesma rogersi Hall

Pl. 15, fig. 19, 20

Leptodesma rogersi Hall, 1883, pl. 21, fig. 1-9. — Hall, 1885, p. 176, pl. 21, fig. 1-9.

Leptodesma rogersi Grabau and Shimer, 1909, p. 426, fig. 556, b. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 254, pl. 29, fig. 7-10. — Shimer and Shrock, 1944, p. 385, pl. 149, fig. 13.

Shell small, prosocline, aviculoid in outline; posterior margin of wing concave; valves depressed convex.

Beak less than one-third valve length behind anterior margin, scarcely elevated above hinge line.

Ear extends forward either parallel with or slightly oblique to hinge.

Wing flat, sharply separated from shell body, posteriorly produced along hinge.

Surface bears concentric striae; striae numerous, fine, evenly and distantly spaced, continue on ear and wing; few concentric rugae on some specimens.

Measurements: length—6 to 8 mm; height—5 to 6 mm.

Relationships.—This species is characterized by its small size, its obliquely aviculoid outline, and its extended posterior wing.

Genus Pterochaenia Clarke

Pterochaenia fragilis (Hall)

Pl. 15, fig. 21

Avicula fragilis Hall, 1842, p. 222, fig. 94, 1, 2.

Aviculopecten fragilis Miller, 1877, p. 184.

Lunulicardium fragile Hall, 1870, p. 97. — Hall, 1885, p. 434, pl. 71, fig. 1-14.

Pterochaenia fragilis Grabau and Shimer, 1909, p. 428, fig. 556, f-i. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 632, pl. 62, fig. 5-7. — Shimer and Shrock, 1944, p. 385, pl. 149, fig. 16.

Shell small, prosocline, subtrapezoidal to elongate-ovoid in outline; valves depressed convex; posterior margin meets hinge line obliquely;

hinge line equals two-thirds of shell length; position of greatest length two-thirds of valve height below dorsal margin; length/height ratios average 1.

Beak at anterior margin, appressed, not elevated above hinge line.

Ear narrow, flange-like, along anterior margin, slightly wider at dorsal than at ventral end; narrow expanded area similar to a wing behind umbonal slope.

Surface bears unevenly spaced concentric undulations.

Relationships.—This species is characterized by its small size, its subovate outline, and its narrow, flange-like expansions on either side of the beak.

Genus Actinopteria Hall

Actinopteria decussata (Hall)

Pl. 15, fig. 22-26

Avicula descussata Hall, 1843, p. 203.

not *Avicula decussata* Rogers, 1858, p. 827, fig. 657.

Pteronites decussata Miller, 1877, p. 202.

Actinopteria decussata Hall, 1883, pl. 17, fig. 24, 28; pl. 18, fig. 1-15. — Hall, 1885, p. 111, pl. 17, fig. 24, 28; pl. 18, fig. 1-15; pl. 20, fig. 19; pl. 84, fig. 4. — Grabau and Shimer, 1909, p. 449, fig. 591, c. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 258, pl. 30, fig. 5-8. — Shimer and Shrock, 1944, p. 391, pl. 152, fig. 18.

Shell medium to large in size, prosocline, obliquely pterinoid in outline; posterior margin concave, inclined 25 to 40 degrees from hinge line.

Valves similar in outline; left valve convex; right valve depressed convex to flattened.

Beak about one-fifth of hinge length behind anterior margin, prominent, elevated slightly above hinge line.

Ear small, confined to dorsal one-third of shell; well-defined sulcus inclined or nearly vertical.

Wing large, nearly flat to slightly concave, extends from beak posteriorly almost to position above posterior extremity, with sharply incurved posterior margin.

Surface of left valve decussate; concentric striae prominent, spaced about 2 per 2 mm near margins; strong radial costae, about 4 per 2 mm near margin, alternate with faint radial striae; ornament continues on ear and wing.

Surface of right valve relatively smooth except for faint concentric striae on shell body and cancellate ornament on wing.

Measurements: length—10 to 31 mm; height—5.5 to 20 mm; convexity—1 to 2 mm.

Relationships.—Actinopteria decussata is distinguished from *A. subdecussata* by its more distinctly decussate ornament, and by the more nearly equal convexity of the two valves. Hall (1884, p. 113) states that the radial ribs of *A. decussata* are more rounded, and the anterior ear larger than on *A. subdecussata,* but these features are not definitive in this collection. Other diagnostic features of this species are the extreme obliquity of the shell body, and the presence of finer radii between the major costae.

Specimens of this species in this collection generally are smaller than those described from New York by Hall.

Genus Modiella Hall

Modiella pygmaea (Conrad)

Pl. 15, fig. 27

Pterinea pygmaea Conrad, 1842, p. 251, pl. 13, fig. 15.
Cypricardinia pygmaea Miller, 1877, p. 188.
Modiella pygmaea Hall, 1883, pl. 76, fig. 9-20. — Hall, 1885. — Grabau and Shimer, 1909, p. 456, fig. 606, d. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 261, pl. 31, fig. 1-5. — Shimer and Shrock, 1944, p. 393, pl. 153, fig. 11.

Shell small, prosocline, obliquely ovate in outline; anteroventral margin inclined about 50° to hinge line; dorsal margin somewhat arcuate, declining anteriorly; height of shell at beaks is one-third that at posterior end of hinge line.

Beak just behind anterior margin, weakly developed, not elevated above hinge line.

Surface bears closely spaced, fine, radial and concentric striae.

Measurements: length—7 mm; height—6 mm; convexity—1.5 mm.

Relationships.—This species is represented by two specimens from the Frame Member of the Mahantango Formation in Perry County. Externally, *Modiella pygmaea* is like *Modiola* with a constriction in the anteroventral margin marking the position of a byssal sinus. Prosser and Kindle (1913, p. 261) remark that there is no significant difference between Maryland specimens and New York specimens of this species, and that the species can be recognized readily by its small size, its ovate outline with short anterior and broad posterior ends, its auriculate anterior margin, and its curved, radiating striae.

The specimens from Pennsylvania are smaller than those from New York described by Hall, and those from Maryland described by Prosser and Kindle.

Genus Conocardium Bronn

Conocardium concinnum Hall

Pl. 15, fig. 28

Conocardium concinnum Hall, 1883, pl. 68, fig. 26, 27. — Hall, 1885, p. 414, pl. 68, fig. 26, 27.

Shell small, subovate in ventral outline; greatest thickness at middle of shell; viewed ventrally, posterior margin is broadly convex, and anterior margin is nearly straight to slightly concave.

Surface radially costate; costae number 16 on single specimen, somewhat more closely spaced anteriorly than posteriorly.

Measurements: length—11.5 mm; convexity—4.5 mm.

Relationships.—Conocardium concinnum is recognized by its small size. Immature specimens of *C. cuneus* resemble this species, but they have more numerous and finer costae. In addition, *C. concinnum* is more abruptly truncate posteriorly, but this characteristic is not observable on the specimen in this collection.

Conocardium normale Hall?

Pl. 15, fig. 29

Conocardium normale Hall, 1883, pl. 68, fig. 17-19. — Hall, 1885, p. 411, pl. 68, fig. 17-19. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 257, pl. 30, fig. 1, 2.

Shell large, subtrigonal in lateral outline; posterior margin abruptly truncated by nearly erect umbonal ridge; valve moderately convex.

Surface radially costate; costae strong, number 17 on single specimen in collection, curve slightly upward toward anterior end.

Specimen measures 50 mm in length from anterior margin to umbonal ridge.

Relationships.—This species is represented in this collection by an incomplete left valve. *Conocardium normale* can be distinguished from other species of *Conocardium* by its large size, and by the fine striae between the more prominent costae. The single specimen in this collection agrees in general characteristics with this species, but the specimen is too imperfectly preserved and incomplete to permit positive identification.

Section D. Isodonta

Superfamily Pectinacea

Genus Aviculopecten McCoy

Aviculopecten bellus (Conrad)

Pl. 15, fig. 30

Avicula bella Conrad, 1841, p. 54.

Aviculopecten bellus Hall, 1883, pl. 2, fig. 5, 6, 9. — Hall, 1885, p. 35, pl. 2, fig. 5, 6, 9, pl. 81, fig. 8.

Shell small, aviculoid in outline.

Ear mucronate, with broad sulcus adjacent to shell body.

Wing concave, extends nearly two-thirds of hinge length behind beak, margin deeply concave.

Surface of left valve bears fine radial striae; striae increase by intercalation, separated by flat interspaces; concentric striae widely and more or less evenly spaced; ear and wing bear less distinct radial and concentric ornament than shell body.

Measurements: hinge length—18 mm; height—9 mm; convexity—1 mm.

Relationships.—This species is very much like *A. insignis,* but the body of the shell is more inclined, and the hinge is more produced and mucronate posteriorly. The single specimen of this species is broken; therefore, measurements of height and convexity are only approximate.

Aviculopecten insignis Hall

Pl. 15, fig. 31

Aviculopecten insignis Hall, 1883, pl. 1, fig. 8; pl. 3, fig. 13. — Hall, 1885, p. 34, pl. 1, fig. 8; pl. 3, fig. 13; pl. 81, fig. 7.

Shell small, elongate-aviculoid in outline; valves depressed convex; anterior and umbonal slopes converge normally to slightly obliquely at beak.

Anterior ear not preserved on specimens in collection.

Wing concave, extended along hinge line, with incurved posterior margin.

Surface of right valve bears radial costae; costae tubular, number 2 per 1 mm at ventral margin, increase by bifurcation, separated by narrow interspaces; concentric ornament weak except on wing; radial ornament weak on wing.

Measurements: hinge length—12 mm; height—10 to 11 mm; convexity—1 mm.

Relationships.—This species differs from *A. bellus* in the more erect shell form and the less extended posterior wing. The difference in the character of the surface ornament, i.e. radial striae on *A. bellus,* compared with tubular costae on *A. insignis,* represents a difference between species; the right valves of these two species have similar ornament, as do the left valves.

Measurements of obliquity and wing extension of several of Hall's illustrations of these two species (Hall, 1885, pl. 1, 2, 3, 81) have been plotted and, although a wide range in these two characters is apparent within each of the species, the separation on the basis of these criteria seems valid. All illustrated specimens of *A. insignis* are more erect and have less extended wings than the illustrated specimens of *A. bellus.* Measurements of specimens from the Mahantango Formation in south-central Pennsylvania fall outside the ranges of both species from New York.

Aviculopecten equilatera (Hall)

Pl. 15, fig. 32

Avicula equilatera Hall, 1843, p. 180, text fig. 7; p. 181, table illus. 39, fig. 7.

Aviculopecten equilatera Hall, 1859, p. 89. — Whitfield, 1893, p. 445, pl. 7, fig. 16. — Kindle, 1912, p. 93, pl. 8, fig. 2, 3. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 265, pl. 32, fig. 3, 4.

Shell small, acline, subequilateral, subcircular in outline; valves depressed convex; length/height ratio for single specimen 1.14.

Beak located near middle of hinge.

Ear small, length one-fourth of shell length, height one-fourth of shell height, flattened, anterior margin nearly straight and vertical.

Wing similar to ear, but not so high.

Surface bears approximately 15 primary radial costellae and nearly the same number of secondary costellae; fine concentric striae and 3 or 4 concentric undulations; ear with concentric striae and about 4 costellae; wing with concentric striae and 1 costella.

Measurements: length—4 mm; height—3.5 mm; convexity—less than 1 mm.

Relationships.— This diminutive species is characterized by its more or less erect form with the anterior ear and posterior wing about equally developed, and the beak situated near the middle of the hinge.

Genus Pterinopecten Hall

Pterinopecten (Pseudaviculopecten) princeps (Conrad)

Pl. 16, fig. 1-3

Monotis princeps Conrad, 1838, p. 117.
Avicula parilis Conrad, 1842, p. 239, pl. 12, fig. 9.
Aviculopecten princeps Hall, 1883, pl. 5, fig. 18, 19, 23, 24; pl. 24, fig. 7. — Hall, 1885, p. 1, pl. 1, fig. 10, 11; pl. 5, fig. 18, 19, 23, 24; pl. 6, fig. 1-9; pl. 24, fig. 7; pl. 81, fig. 13-17. — Grabau and Shimer, 1909, p. 487, fig. 650, b. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 263, pl. 31, fig. 10, 11; pl. 32, fig. 1, 2.
Pterinopecten (pseudaviculopecten) princeps Shimer and Shrock, 1944, p. 403, pl. 160, fig. 3.

Shell medium to large, subequilateral, erect-aviculoid in outline; length/height ratio approximately 1; small specimens are proportionately higher and large specimens are proportionately longer.

Beak just forward of middle of hinge, slightly appressed, scarcely elevated above hinge line.

Ear small, anterior margin sinuate, with indistinct sulcus.

Wing larger than ear, flattened, posterior margin broadly concave.

Surface bears alternating coarse and fine, subangular radial costellae; costellae spaced about 9 per 4 mm near ventral margin, increase by intercalation, separated by furrows that are broader and flatter than costellae, continues on wing but not on ear; fine concentric striae marginally present, continue on ear and wing; few faint growth varices on large specimens.

Relationships.—This species is recognized by its erect-aviculoid form, its usually larger size, the alternating coarse and fine radial ornament, and the general absence of concentric ornament. The small, measured specimen of this species resembles *Aviculopecten lautus* and *A. exactus,* but it differs from the former in lacking radial ornament on the ear, and it differs from *A. exactus* in being more erect and having its posterior extremity much more ventrally situated.

Pterinopecten hermes Hall?

Pl. 15, fig. 33-35

Pterinopecten hermes Hall, 1883, pl. 17, fig. 13-15. — Hall, 1885, p. 64, pl. 17, fig. 13-15.

Shell small, subequilateral, prosocline, inverted subtrapezoidal in outline; valves depressed convex; greatest length at hinge; length/height ratios average 1.45.

Beak just forward of middle of hinge, slightly appressed, not elevated above hinge.

Ear and wing flattened.

Surface cancellate; fine radial striae spaced 3 to 4 per 1 mm near margin, increase by intercalation about two-thirds distance below hinge; intervening furrows broad and flat; concentric striae spaced 2 per 1 mm, offset radial striae; radial and concentric ornament continues on wing; radial striae on ear somewhat plicate.

Measurements: length—6.5 to 8 mm; height—4.5 to 5.5 mm; convexity—less than 1 mm.

Relationships.—Specimens of this species range in obliquity from 60 to 80 degrees. Although the ornament also shows considerable variation, the concentric striae that offset the radial ornament is a distinctive feature of *P. hermes.* This species is similar in form to *P. laeus,* but the hinge line is proportionately longer and the radiating striae stronger and more distinctly alternating (Hall, 1884, p. 65).

Specimens of this species from New York are considerably larger than any collected from the Mahantango Formation in south-central Pennsylvania.

Section E. Dysodonta

Superfamily Mytilacea

Genus Modiomorpha Hall

Modiomorpha concentrica (Conrad)

Pl. 16, fig. 4-6

Pterinea concentrica Conrad, 1838, p. 116.

Cypricardites concentrica Conrad, 1841, p. 52.

Modiomorpha concentrica Hall, 1870, p. 73. — Hall, 1885, p. 275, pl. 34, fig. 9, 10; pl. 35, fig. 1-5; pl. 36, fig. 1-16. — Grabau and Shimer, 1909, p. 515, fig. 692d, 694d. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 266, pl. 32, fig. 5-9. — Shimer and Shrock, 1944, p. 409, pl. 164, fig. 2.

Shell large, inequilateral, prosocline, elongate-ovoid in outline; anterior margin sharply rounded; ventral margin broadly rounded to slightly concave; posterior margin regularly rounded; cardinal line straight, length more than one-half of shell length; umbonal slope well defined; greatest length one-third distance above ventral margin; shell height at beak three-fourths of that as posterior and of cardinal line; length/height ratio about 2.5.

Surface bears concentric striae; striae 8 per 5 mm near margin, 12 per 5 mm near beak.

Measurements: length—62 mm; height—21 mm; convexity—9 mm.

Relationships.—Modiomorpha concentrica differs from *M. mytiloides* in its more prominent and arcuate umbonal slope, its less produced posterior margin, and its more distinct concentric ornament. *Modiomorpha alta* is proportionately higher than either of these species.

In the collection being studied, this species is represented by fragmentary specimens; however, the specimens are complete enough to permit identification.

Genus Goniophora Phillips

Goniophora hamiltonensis (Hall)

Pl. 16, fig. 7

Sanguinolites hamiltonensis Hall, 1870, p. 36.

Goniophora hamiltonensis Miller, 1877, p. 192. — Hall, 1885, p. 296, pl. 43, fig. 8-15, 17-21. — Grabau and Shimer, 1909, p. 519, fig. 699, c. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 271, pl. 33, fig. 11-13. — Shimer and Shrock, 1944, p. 413, pl. 164, fig. 13.

Shell large, trapezoidal in outline; posteriorly subtruncate; valves moderately convex; anterior extremity narrower than posterior; ventral margin converges with posterior margin to form acute angle at base of sharp umbonal carina that extends diagonally across length of shell from beak; greatest convexity near middle of umbonal carina.

Surface bears concentric striae; striae somewhat irregular, coarse, increase by intercalation toward posterior, indistinct near beak.

Measurements: length—approximately 75 mm; height—approximately 25 mm; convexity—approximately 10 mm.

Relationships.—This species is represented in this collection by one nearly complete cast of a left valve, and several fragments. Measurements given above are minimum values because not all of the margins can be seen. *Goniophora hamiltonensis* differs from *G. rugosa* in having a more distinct umbonal carina, in having a more obviously truncate posterior margin, and in lacking the rugose concentric ornament of that species.

Order Teleodesmacea

Superfamily Cypricardiacea

Genus Cypricardella Hall

Cypricardella bellastriata (Conrad)

Pl. 16, fig. 8-10

Microdon bellastriata Conrad, 1842, p. 247, pl. 13, fig. 12. — Rogers, 1858, p. 827, fig. 660.

Microdon (Cypricardella) bellistriatus Hall, 1885, p. 308, pl. 42, fig. 17-20; pl. 73, fig. 7-22.

Cypricardella bellistrata Grabau and Shimer, 1909, p. 535, fig. 727, c, d. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 273, pl. 34, fig. 1-4.

Shell medium in size, prosocline, subquadrate in outline; valves nearly flat; anterior end produced and sharply rounded; ventral margin nearly straight to very broadly rounded; posterior end truncate, with straight and nearly vertical margin; cardinal line subparallel to ventral margin, slightly arcuate; umbonal slope faint; length/height ratios average 1.53.

Beak located one-fourth to one-third of shell length behind anterior margin, not elevated above posterior portion of cardinal line.

Surface bears concentric striae, striae evenly and closely spaced, numbering 2 to 3 per 1 mm, bend abruptly upward and forward on umbonal slope; surface distantly lamellose on some specimens.

Measurements: length —18 to 37 mm; height—9 to 22.5 mm; convexity—less than 1 mm.

Relationships.—This species is represented in this collection by numerous impressions, most of which are incomplete, but preserved well enough for specific identification. *Cypricardella bellastriata* is readily recognized by its subquadrate outline and its uniformly spaced, regular concentric striae. It differs from *C. gregarius* in its broader cardinal slope and less oblique posterior margin. *Cypricardella complanatus* is quite similar to this species, but it is larger and more elongate, and the striae are fasciculate and less regular than in *C. bellastriata.*

Hall specimens of this species, as illustrated (1885, p. 309), range in length from 28 to 46 mm, whereas specimens in this collection range in length from 13 to 37 mm.

Cypricardella tenuistriata (Hall)

Pl. 16, fig. 11, 12

Microdon tenuistriata Hall, 1870, p. 32.

Microdon (Microdonella) (Eodon) tenuistriata Hall, 1883, pl. 73, fig. 23-27, 29, 30; pl. 74, fig. 20, 21.

Microdon (Cypricardella) tenuistriata Hall, 1885, p. 310, pl. 42, fig. 16; pl. 73, fig. 23-30; pl. 74, fig. 20, 21.

Cypricardella tenuistriata Grabau and Shimer, 1909, p. 534, fig. 727, a, b. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 275, pl. 34, fig. 5. — Shimer and Shrock, 1944, p. 415, pl. 166, fig. 2.

Shell large, prosocline, subquadrate in outline; valves nearly flat, with greatest convexity on umbonal slope; anterior margin nearly straight

and inclined about 60° from cardinal line; ventral margin broadly rounded, subparallel to cardinal line; postero-ventral extremity sharply rounded; posterior margin nearly straight, truncate, inclined less than 60° to cardinal line; length/height ratios average 1.01 for 2 specimens.

Beaks appressed, located about one-fifth of shell length behind anterior margin.

Surface bears fine, unevenly spaced, somewhat fasciculate concentric striae that are obsolete near beak.

Measurements: length—47 to 59 mm; height—35 mm; convexity—2.5 to 4 mm.

Relationships.—Compared with *C. bellastriata,* this species generally is larger, has a more rounded ventral margin, has a less produced anterior end, has a more inclined posterior margin, and possesses concentric striae that are not as well defined nor as regular and evenly spaced as in *C. bellastriata.*

Specimens of this species from the Mahantango Formation are somewhat larger than those described by Hall from the Hamilton Group in New York (1885, p. 311).

Genus Cypricardinia Hall

Cypricardinia indenta (Conrad)

Pl. 16, fig. 13

Cypricardites indenta Conrad, 1842, p. 244, pl. 12, fig. 12.
Cypricardinia indenta Hall, 1870, p. 83. — Hall, 1885, p. 485, pl. 79, fig. 6-16; pl. 96, fig. 2. — Grabau and Shimer, 1909, p. 536, fig. 729c. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 276, pl. 34, fig. 6-10. —Shimer and Shrock, 1944, p. 417, pl. 166, fig. 10.

Shell small, elongate-subovate in outline; valves depressed convex; anterior margin sharply rounded; ventral margin nearly straight, slightly constricted near middle of shell; length/height ratios for 2 specimens average 1.82.

Surface bears broad concentric lamellae; lamellae number 9 to 11 per specimen, crowded anteriorly and more distant posteriorly; fine radial striae on lamellae can be seen on external molds.

Measurements: length—6.5 to 11 mm; height—4 to 6 mm; convexity—2 mm.

Relationships.—This species is characterized by its small size, its elongate outline with a somewhat constricted ventral margin, and its broad, distantly spaced concentric lamellae.

Specimens of this species from the Mahantango Formation of Pennsyl-

vania are somewhat smaller than those from the Hamilton Group of New York, as described by Hall (1885, p. 485).

Superfamily LUCINACEA

Genus PARACYCLAS Hall

PARACYCLAS LIRATA (Conrad)

Pl. 16, fig. 14-17

Posidonia lirata Conrad, 1838, p. 16, unnumbered pl., fig. 12.
Lucinda (Paracyclas) lirata Hall and Whitfield, 1872, p. 200.
Paracyclas lirata, 1885, p. 441, pl. 72, fig. 2-19; pl. 95, fig. 19. — Grabau and Shimer, 1909, p. 555, fig. 760b. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 277, pl. 34, fig. 11-14. — Shimer and Shrock, 1944, p. 423, pl. 168, fig. 14.

Shell small to large, subequilateral, prosocline to acline, subcircular to subquadrate in outline; valves depressed convex to nearly flat; dorsal margin subtruncate; length/height ratio about 1.

Surface bears fine concentric striae and prominent, unevenly spaced rugae.

Escutcheon defined by shallow groove subparallel to cardinal line behind beak.

Measurements: length—8 to 24 mm; height—8 to 23 mm; convexity—1 to 3 mm.

Relationships.—Paracyclas lirata is very much like *P. elliptica,* but that species generally is larger and has less prominent concentric rugae that are more like broad undulations. *Paracyclas lirata* exhibits considerable range in characteristics such as size and ornament, and two more or less distinct morphotypes can be recognized: one form is smaller, more quadrate in outline, less erect, and proportionately longer than the other. However, inasmuch as the two morphotypes occur together stratigraphically, they are not treated separately here.

Class GASTROPODA

Subclass PROSOBRANCHIA

Order ARCHAEOGASTROPODA

Genus PTOMATIS Clarke

PTOMATIS PATULUS (Hall)

Pl. 16, fig. 18

Bellerophon patulus Hall, 1843, p. 196, fig. 1. — Hall, 1879, p. 100, pl. 22, fig. 17-30; pl. 24, fig. 3-5; pl. 26, fig. 10-12.

Ptomatis patulus Grabau and Shimer, 1909, p. 624, fig. 841.
Bellerophon (Patellostium) patulus? Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 287, pl. 25, fig. 14.
Ptomatis patulus Knight, in Shimer and Shrock, 1944, p. 441, pl. 177, fig. 1-4.

Shell bellerophontoid, without selenizone; length/width ratios average 0.76 for two specimens; aperture transversely elliptical in outline; in dorsal view, spire extends slightly beyond posterior margin of nearly flat apertural flange.

Surface of shell smooth except for few faint transverse striae that curve posteriorly at median position of spire.

Measurements: shell length—32 to 44 mm; apertural width—38 to 65 mm; spire width—16 to 23 mm.

Relationships.—Two natural casts of this species are present in this collection; the smaller one is considerably distorted and the other is somewhat flattened. Measurements given for the smaller of the two specimens, therefore, are only approximate.

This species, the genotype for *Ptomatis* differs from other bellerophontids in lacking the selenizone. Furthermore, the nearly smooth surface is quite unlike any other similar form.

New York state specimens of *P. patulus* as described by Hall (1879, p. 100) commonly measure one and three-fourths and rarely two and one-half inches in width, comparing favorably in size with the specimens from Pennsylvania.

Genus Bucanopsis Ulrich and Scofield

Bucanopsis leda (Hall)

Pl. 16, fig. 19

Bellerophon leda Hall, 1861, p. 30. — Hall, 1879, p. 110, pl. 23, fig. 2-16.
Bucanopsis leda Grabau and Shimer, 1909, p. 623, fig. 837.
Bellerophon (Bucanopsis) leda Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 285, pl. 36, fig. 1-3.
Bucanopsis leda Knight, in Shimer and Shrock, 1944, p. 443, pl. 178, fig. 23.

Shell bellerophontoid; length/width ratio 0.87 for one specimen; aperture broadly cordate in outline; median selenizone crossed by numerous closely spaced lunulae, 1 mm wide, extends to anterior margin where it is marked by well-defined slit.

Surface bears nearly flat, broad revolving costae, costae number 1 per 1 mm at anterior margin, absent on postero-dorsal surface of aperture, they are crossed by very fine, closely spaced, transverse striae; transverse

striae continue onto apertural flange as delicate, closely spaced growth lines.

Measurements: shell length—23 mm; apertural width—26.5 mm; spire width—11 mm.

Relationships.—This species is represented in this collection by numerous molds and casts, and by a partly exfoliated shell. The transverse striae combined with the more prominent revolving costae give this species a distinctive appearance that is similar in general but differing in detail from the ornament of *B. lyra*. In that species, the transverse striae are not so well defined, and, in addition, the shell is not so ventricose. Hall (1879, p. 110) has commented on the gradational nature of these two species.

Specimens from the Hamilton of Pennsylvania are generally somewhat larger than those from the Hamilton of New York. Only one specimen complete enough to measure has been collected in Pennsylvania and that measures an inch in width, but judging from the fragmentary specimens, their size is approximately the same. Specimens from New York, on the other hand, are commonly three-fourths of an inch wide, rarely 1 to 1¼ inches wide.

Genus Crenistriella Knight

Crenistriella crenistria (Hall)

Pl. 16, fig. 20

Bellerophon crenistria Hall, 1876, pl. 25. — Hall, 1879, p. 116, pl. 25, fig. 16-18.

Crenistriella crenistria Knight, 1945, p. 334.

Shell planispiral, lacking expanded aperture of other bellerophontid genera; length/width ratio of one specimen 1.10; last whorl of spire 6.5 mm wide; spire with medial, narrow selenizone that is slightly depressed.

Surface bears numerous fine, spiral striae that are crossed obliquely by numerous, fine grooves to produce lineally arranged papillae; surface of selenizone regularly papillose, lacking lunulae.

Measurements: shell length—11 mm; apertural width—10 mm; spire width—6.5 mm.

Relationships.—This species is represented in this collection by several external molds and natural casts of incomplete individuals. The most complete specimen is a natural cast of the dorsal portion of the body whorl. All specimens display the typical spiral crenellae that enable one to differentiate this species from all others. Hall (1879, p. 116) mentions the variability of the surface ornament within this species, but indicates

that most forms have "interrupted longitudinal striae with intermediate spaces reaching the even surface of the shell".

Genus Bembexia Oehlert

Bembexia sulcomarginata (Conrad)

Pl. 16, fig. 21-23

Pleurotomaria sulcomarginata Conrad, 1842, p. 272, pl. 16, fig. 13. — Hall, 1879, p. 69, pl. 19, fig. 8-17.

Bembexia sulcomarginata Grabau and Shimer, 1909, p. 647, fig. 883.

Pleurotomaria (Bembexia) sulcomarginata Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 280, pl. 35, fig. 1-5.

Bembexia sulcomarginata Knight, in Shimer and Shrock, 1944, p. 457, pl. 184, fig. 25, 26.

Shell turbinate; apical angle about 100°; body whorl width about one-half of shell width, length somewhat more than one-half of shell length; spire consists of 3 whorls; whorls subcarinate in profile; selenizone narrow, bears faint lunulae.

Surface bears fine, closely spaced transverse striae; striae number 2 per 1 mm, somewhat more widely spaced on body whorl, extend from spiral suture across ramp to low shoulder just above selenizone, curve backward from spiral suture so that peripheral end of stria is from 4 to 6 striae behind its axial end, may be obsolete on outer half of body whorl.

Measurements: shell length—10 to 25 mm; shell width—15.5 to 33.5 mm.

Relationships.—Bembexia sulcomarginata is represented in this collection by many internal molds and numerous casts. It is characterized by its turbinate form, its spire with about three whorls, and by its fine, transverse striae that terminate more or less peripherally at a shoulder just above the selenizone. *Bembexia capillaria,* on the other hand, shows several revolving striae, in addition to the transverse striae, that produce a reticulate surface texture.

Specimens of *B. sulcomarginata* from Fishertown are discoidal, but this is believed to be the result of flattening rather than representing a specific difference.

This species from *B. laevis* in having a more turbinate outline, and in having transverse striae; *B. laevis* is discoidal and lacks transverse striae.

Bembexia capillaria (Conrad)

Pl. 17, fig. 1

Pleurotomaria capillaria Conrad, 1842, p. 271, pl. 16, fig. 11. — Hall, 1879, p. 77, pl. 20, fig. 18-21.

Pleurotamaria (Gyroma) capillaria Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 282, pl. 35, fig. 6-8.

Bembexia capillaria Knight, in Shimer and Shrock, 1944, p. 457, pl. 184, fig. 30.

Shell with narrow selenizone bearing faint lunulae.

Surface bears numerous revolving and transverse striae; revolving striae stronger and more widely spaced than transverse striae, may be of uniform strength or alternatingly strong and weak; low nodes at intersections of revolving and transverse striae.

Relationships.—Fragments of several external molds exhibit the surface ornament characteristic of this species. The numerous revolving striae of *B. capillaria* distinguish it from other species of *Bembexia*. According to Hall (1879, p. 78), imperfectly preserved individuals of this species may be confused with those of *Cyclonema hamiltoniae;* however, that species has no selenizone, and the portion of the whorls adjacent to the spiral sutures lacks revolving striae.

Bembexia laevis Ellison n. sp.

Pl. 17, fig. 2-4

Shell discoidal in outline; apical angle about 140°; length/width ratios average 0.32 for 4 specimens; body whorl width is 0.38 of shell width, length is 0.75 of shell length; spire consists of 3 whorls; whorls slightly elevated just below spiral suture to produce a very narrow shelf; selenizone unknown; aperture unknown.

Surface nearly smooth, bears very faint transverse striae that are directed backward.

Measurements of specimens are given in the accompanying table.

Shell length	*Shell width*	*Body whorl Length*	*Body whorl Width*	*L/W*	*Apical angle*
4.5 mm	21 mm	....	7.5 mm	0.22	...
8.0	27	6.5 mm	9.5	0.30	...
10.0	31	7.0	10.0	0.31	132°
15.0	35	11.0	13.5	0.43	145

Relationships.—Numerous external and internal molds of this species have been collected. *Bembexia laevis* differs from *B. sulcomarginata* in its relatively smooth exterior and larger size, as well as in its discoidal outline. This species probably represents an evolutionary departure from *B. sulcomarginata,* a species which, in general, precedes *B. laevis.*

Figured specimens of this new species are deposited in the U. S. National Museum.

Genus Loxonema Phillips

Loxonema delphicola Hall

Pl. 17, fig. 5, 6

Loxonema delphicola Hall, 1861, p. 24. — Hall, 1879, p. 47, pl. 13, fig. 19-25; pl. 14, fig. 1, 2. — Grabau and Shimer, 1909, p. 693, fig. 990. — Knight, in Shimer and Shrock, 1944, p. 461, pl. 186, fig. 17, 18.

Shell dextral, turreted; apical angle averages 23° for three specimens; length/width ratios average 3.0; spire with approximately 5 whorls that increase in length gradually toward anterior; narrow, flat band at position of spiral suture; suture dips about 10 degrees from horizontal.

Surface bears closely spaced transverse striae; striae strong, number 2 per 1 mm, concave in the direction of coiling, with ends of each stria more or less aligned longitudinally, nearly obsolete on narrow band at spiral suture.

Approximate measurements: shell length—21 to 35 mm; shell width—7 to 11 mm.

Relationships.—This species is represented in this collection by numerous incomplete impressions and several incomplete natural casts. It is distinguished from *L. hamiltoniae* by the narrow band contiguous with the spiral suture. Hall (1879, p. 47) states that the volutions of *L. hamiltoniae* are more numerous and the striae more strongly bent than in *L. delphicola,* but these differences are not apparent from his illustrations (pl. 13, fig. 15, 17, 19-23). The specimens of *L. delphicola* from New York are proportionately wider than the specimens in this collection, although specimens from both areas are similar in size.

Genus Holopea Hall

Holopea macrostomus Hall?

Pl. 17, fig. 7

Macrocheilus (Holopea) macrostomus Hall, 1861, p. 21.

Shell turbinate; apical angle 100°; spire with at least three volutions; body whorl broadly rounded in lateral outline except for sharply curving shoulder, equals nearly three-fourths of shell height; dip of spiral suture about 10°; aperture unknown, but body whorl flares out slightly at aperture.

Surface nearly smooth, bears unevenly spaced transverse growth striae.

Measurements: shell length—20.5 mm; body whorl length—15 mm; shell width—22 mm.

Relationships.—This species is represented by one natural cast of the side opposite at the aperture. The specimen is assigned with question to this species on the basis of shell and body whorl outline, and the transverse growth lines.

Genus Cyclonema Hall

Cyclonema sp.

Pl. 17, fig. 8

Shell turbinate; apical angle about 90°; selenizone not apparent on specimens.

Surface bears revolving striae and very faint transverse striae.

Relationships.—One distorted and poorly preserved natural cast, and numerous parts of impressions are referred to this genus. The absence of a selenizone, and the predominance of revolving striae are features which differentiate this genus from *Bembexia.*

Grabau, in concert with Ulrich, has commented on the impropriety of referring post-Silurian species to the genus *Cyclonema* (1902, p. 927), but the question of whether or not species from the Devonian referred by Hall and others to the genus *Cylconema* actually belong in this genus is beyond the scope of the present investigation.

Genus Platyceras Conrad

Platyceras sp.

Pl. 17, fig. 9, 10

Shell bucciniform, uncoiling; spire with less than one whorl, width less than 0.2 of shell width; body whorl very rapidly expanding.

Surface smooth.

Measurements: shell length—10 to 14.5 mm; apertural width— 10 to 13 mm.

Relationships.—Three crushed natural casts are referred to the genus *Platyceras,* but specific identification has not been possible, owing to the poor preservation of the specimens; minute details are necessary for specific recognition within this genus.

Platyceras (Platyostoma) euomphaloides Hall

Pl. 17, fig. 11

Platyostoma euomphaloides Hall, 1876, pl. 9. — Hall, 1879, p. 25, pl. 10, fig. 27-29.

Shell naticiform, dextral, paucispiral with 2 whorls in spire; apical angle about 115°; whorls regularly rounded, not angulate; body whorl length is three-fourths of shell length; basal margin of body whorl holostromatous, very slightly convex, inclined toward aperture; aperture suborbicular.

Surface bears fine growth striae that are somewhat fasciculate; spiral ornament lacking.

Measurements: shell length—13 and 39 mm; shell width—15 and 54 mm.

Relationships.—This species is represented in this collection by one flattened natural cast, and an internal and external mold of another individual. The body whorl of this species is proportionately higher than that of *Naticonema lineata,* the species it most nearly resembles, and the margins of the body whorl are less sharply rounded than in that species. Furthermore, specimens of *N. lineata* commonly have spiral as well as transverse surface striae, whereas this species lacks spiral ornament.

Genus Naticonema Perner

Naticonema lineata (Conrad)

Pl. 17, fig. 12

Platyostoma lineata Conrad, 1842, p. 276, pl. 17, fig. 7. — Hall, 1879, p. 21, pl. 10, fig. 1-21.

Diaphorostoma lineatum Grabau and Shimer, 1909, p. 680, fig. 953. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 298, pl. 37, fig. 7-12.

Naticonema lineata Knight, in Shimer and Shrock, 1944, p. 475, pl. 194, fig. 6, 7.

Shell very low-spired, consists of 3 whorls; whorls depressed with regularly rounded outlines; aperture low, subelliptical, inclined about 30° from horizontal.

Surface reticulate; transverse striae fine, closely spaced, crossed by somewhat coarser and more distantly spaced revolving striae.

Measurements of a single specimen of this species are as follows: shell length—18 mm; shell width—36 mm; body whorl length—15.5 mm; apical angle—140°.

Relationships.—One nearly complete exfoliated specimen of this species is present in this collection. The low and rapidly expanding spiral form, as well as the surface ornament, is a characteristic feature of this species. Commonly, *N. lineata* is marked by transverse and revolving striae that are rather delicated and of equal strength. However, the external orna-

ment of this specimen is not typical for the species; this specimen has revolving striae that are somewhat coarser than the transverse striae, producing an ornament similar to that of *Bembexia capillaria*.

Genus IANTHINOPSIS Meek and Worthen

IANTHINOPSIS? sp.

Pl. 17, fig. 13, 14

Shell neritiform, dextral, width is five-sixths of shell length; apical angle 100°; spire small, paucispiral, consists of 3 rounded whorls; body whorl ventricose, broadly rounded, length is 0.8 of shell length; aperture unknown.

Surface nearly smooth, bears faint growth striae preserved only on upper surface of whorls.

Measurements: shell length—7.5 to 22 mm; shell width—6.5 to 16.5 mm.

Relationships.—Ianthinopsis? sp. is similar to *I.*? *hamiltoniae*, but that species has a much higher spire and the shell is more transverse. However, *I.*? sp. exhibits considerable growth variation in the general outline and nature of the spire and body whorl; smaller forms generally are much more transverse and turbinate in form than larger forms.

This species is represented in this collection by numerous external and internal molds; consequently, the weak columella attributed to the genus *Strobeus* (*-Ianthinopsis*) by Keyes (1889, p. 305) cannot be observed. Nevertheless, the outline of mature individuals represented in this collection is more nearly like that of *Ianthinopsis* than any other similar genus, e.g. *Holopea*. Better understanding of generic affinities awaits further study.

Class CEPHALOPODA

Subclass NAUTILOIDEA

Order ORTHOCHOANITES

Genus STRIACOCERAS Flower

STRIACOCERAS TYPUM (Saemann)?

Pl. 17, fig. 15; pl. 19, fig. 16

Marcellue orthocera Vanuxem, 1842, p. 147.
Orthoceras typus Saemann, 1852, p. 165, pl. 20, fig. 1, a-e.
Orthoceras Marcellensis Hall, 1860, p. 106.
Orthoceras typum Hall (in part), 1876, pl. 38.

Orthoceras Marcellense Hall, 1879, p. 278, pl. 38, fig. 4-7, 9; pl. 83, fig. 1-10, 12; pl. 113, fig. 18.
Protokionoceras marcellense Grabau and Shimer, 1909, p. 60, fig. 1264.
Striacoceras typum Shimer and Shrock, 1944, p. 539, pl. 220, fig. 6, 7.

Shell orthoceraconic, diameter as large as 30 mm; septa broadly concave, spaced 1 per 3 to 5 mm; siphuncle subcentral in position, diameter less than one-tenth of shell diameter.

Surface nearly smooth, lacking concentric annulations; concentric striae very fine, wavy, closely spaced.

Maximum shell diameters of 3 incomplete specimens are 19, 21, and 25.

Relationships.—All of the specimens tentatively referred to this species are incomplete. Indeed, only a few chambers are present in any of the specimens, and most of the specimens are internal molds; identification is, therefore, uncertain. None preserve the fine ventral carina that *S. typum* possesses, and the siphuncle is more nearly central in the specimens than in *S. typum*. Nevertheless, the wavy concentric striae are not present on any species other than *S. typum* in the Hamilton Group.

Spyroceras nuntium (Hall)?

Pl. 17, fig. 16, 17

Orthoceras nuntium Hall, 1861, p. 51. — Hall, 1862, p. 79, pl. 8, fig. 3, 4. —Hall, 1879, p. 299, pl. 43, fig. 4-10, 13, 14; pl. 82, fig. 14, 15.
Orthoceras (Spyroceras) nuntium Clarke and Ruedemann, p. 633.
Spyroceras nuntium Grabau and Shimer, 1910, p. 64, fig. 1272. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 316, p. 541, pl. 221, fig. 4, 5.

Shell orthoceraconic, concentrically annulated; annulae spaced 1 per 3 to 6 mm, are prominent transverse ridges separating constricted chambers.

Surface bears fine, evenly and closely spaced longitudinal striae.

Relationships.—This species is represented by numerous fragments of natural casts and external and internal molds. The concentric annulae and the fine longitudinal striae serve to differentiate *Spyroceras* from other genera in the Mahantango Formation. *Spyroceras nuntium* differs from *S. crotalum* in the spacing of the annulae; the annulae are more closely and regularly spaced in *S. nuntium* than in *S. crotalum*. Inasmuch as the specimens show considerable range of annular spacing, and considering the fragmentary nature of the specimens, specific identification is subject to question.

Subclass AMMONOIDEA?

Order EXTRASIPHONATA?

Genus BACTRITES Sandberger

BACTRITES? ACICULUM (Hall)

Pl. 17, fig. 18, 19

Orthoceras aciculum Hall, 1843, p. 243.
Coleolus aciculum Hall, 1879, p. 187, pl. 32A, fig. 11-15 (16?).
Bactrites aciculum Kindle, 1912, p. 104, pl. 9, fig. 3. — Kindle, in Prosser, Kindle, and Swartz, 1913, p. 320, pl. 38, fig. 9; pl. 42, fig. 5.
Bactrites? aciculum Shimer and Shrock, 1944, p. 565, pl. 231, fig. 1, 2.

Shell small to medium in size, orthoceraconic, flattened, bears median cleft; length nearly 6 times maximum diameter.

Surface smooth.

Single nearly complete specimen measures more than 20 mm in length, and 3 mm in maximum diameter.

Relationships.—This species is represented in this collection by numerous natural casts and external molds. It is distinguished from other similar forms in the Mahantango Formation by its acicular outline, flattened profile, and median cleft. *Styliolina fissurella* resembles *Bactrites? aciculum,* but that species is very small and proportionately shorter.

The apparent absence of septa in these specimens, as well as in many specimens referred to this species in the literature, makes generic assignment doubtful.

Class PTEROPODA?

Genus COLEOLUS Hall

COLEOLUS GRACILIS Hall?

Pl. 17, fig. 20

Coleolus? gracilis Hall, 1879, p. 190, pl. 32A, fig. 19. — Grabau and Shimer, 1909, p. 9, fig. 1219, a. — Shimer and Shrock, 1944, p. 526, pl. 214, fig. 18.

Shell medium-sized, orthoceraconic; length about 5 times maximum diameter.

Surface bears transverse striae; striae slightly oblique to shell axis, equal in width and strength to interspaces between striae, rather irregular.

Relationships.—An external and an internal mold represent this species in this collection. *Coleolus gracilis* is differentiated from *C. tenuicinctus* by the predominance of transverse striae. Inasmuch as the speci-

mens in this collection have no longitudinal striae, they are, therefore, regarded as being most closely allied with *C. gracilis*. However, the specific identification is considered tentative.

Genus Styliolina Karpinsky

Styliolina fissurella (Hall)

No fig.

Tentaculites fissurella Hall, 1843, p. 180, fig. 9, 10; p. 222, fig. 4.
Styliola fissurella Hall, 1879, p. 178, pl. 31A, fig. 1-30.
Styliolina fissurella Grabau and Shimer, 1910, p. 16, fig. 1229. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 685, pl. 71, fig. 1-3. — Shimer and Shrock, 1944, p. 526, pl. 215, fig. 53.

Shell minute, elongate-conical in outline, flattened in profile, bears longitudinal median cleft.

Surface smooth.

Measurements: length—1.54 to 3.52 mm; maximum diameter—0.37 to 0.62 mm.

Relationships.—This species is represented in this collection by innumerable external molds and natural casts. *Styliolina fissurella* is distinguished from species of *Tentaculites* by the absence of concentric annulae, from *Bactrites? aciculum* by its smaller size, and from *Styliolina bellistrata* by the absence of fine, longitudinal striae. Such striae are present on *Styliolina fissurella* as described and illustrated by Hall (1879, p. 179; pl. 31A, fig. 23, 24, 31, 32), but in the present study, specimens referred to *S. bellistriata* and *S. fissurella* are found stratigraphically separated, and, therefore, are regarded as separate species.

Styliolina bellistriata Ellison n. sp.

Pl. 17, fig. 21

Styliolina fissurella Hall, 1879, pl. 31A, fig. 23, 24, 32, 33.

Shell minute, elongate-conical in outline; one side of shell bears longitudinal median cleft; other side of shell regularly convex, lacks median cleft.

Surface bears fine, closely spaced, longitudinal striae; growth lines and subdued concentric annulae on few specimens.

Measurements: length—2.40 to 2.65 mm; maximum diameter—0.49 to 0.88 mm.

Relationships.—This species is represented in this collection by numerous external impressions and natural casts. It is differentiated from

Styliolina fissurella by its fine, longitudinal striae and its somewhat less flattened form. Specimens bearing very subdued concentric annulae bear a resemblance to *Tentaculites gracilistriatus,* but such forms are relatively rare.

Specimens identical with these have been included in the species *Styliolina fissurella* by Hall, who attributes the difference in surface ornament to differences in conditions of preservation (1879, pl. 31A, fig. 23, 24, 32, 33). However, inasmuch as the two forms are stratigraphically as well as morphologically distinct in south-central Pennsylvania, they are here considered as separate species.

The figured specimen of this new species is deposited in the U. S. National Museum.

Tentaculites attenuatus Hall

Pl. 17, fig. 22-24

Tentaculites attenuatus Hall, 1876, pl. 26, fig. 19, 20. — Grabau and Shimer, 1910, p. 11. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 301, pl. 37, fig. 21. — Shimer and Shrock, 1944, p. 526, pl. 214, fig. 47.

Shell small, elongate-conical to acicular in outline, circular in cross-section; length is 6 to 9 times maximum diameter.

Surface bears unevenly spaced concentric annulations; annulae number 2 per 1 mm near aperture, more closely spaced near apex; spaces between annulae bear numerous very fine, regularly spaced concentric lirae.

Measurements: length—10 to 13 mm; maximum diameter—1.5 mm.

Relationships.—This species is very similar to *Tentaculites bellulus* except for its uneven spacing of the annulations and its somewhat smaller size.

In this collection, *T. attenuatus* is represented by several external molds and innumerable specimens in which shell material is preserved. In the latter specimens, the hollow axes of the shells have been filled, and these internal molds indicate that the external annulae are not seen internally.

Phylum Arthropoda
Class Trilobita
Order Ptychopariida
Family Proetidae
Genus Proetus Steininger

Proetus rowi (Green)

Pl. 18, fig. 1

Calymene Rowii Green, 1838, p. 406.
Proetus Rowii Hall, 1861, p. 75. — Hall, 1862, p. 103. — Hall and Clarke, 1888, p. 119, pl. 21, fig. 2-6.
Proetus rowi Cleland, 1903, p. 79. — Grabau and Shimer, 1910, p. 301, fig. 1613a. — Shimer and Shrock, 1944, p. 653, pl. 274, fig. 10.

Cephalon semicircular in outline, gibbous; length/width ratio 0.60 for one specimen; glabella subquadrate, tapering slightly forward, width 0.42 of cephalic width; frontal lobe 0.83 of total glabellar length; first lateral lobes ovate, isolated; nearly flat marginal border 2 mm wide; fixigenae small, consisting solely of unfurrowed palpebral lobes; librigenae subtriangular, bear large crescentic holochroal eyes; short genal spines extend to second thoracic segment; surface except border finely pustulose.

Thorax distinctly trilobate, with very convex axis that is 0.41 of thoracic width; axial rings at least 10 in number; pleurae deflected obliquely downward in outer portion; pleural and interpleural furrows well defined; surface finely pustulose.

Measurements: length of cephalon—13.5 mm; width of cephalon—22.5 mm; width of thorax—20.5 mm.

Relationships.—This species is represented in the present collection by one nearly complete cephalon and thorax. The specimen is very similar in all aspects to those illustrated by Hall and Clarke (1888, see especially fig. 6 of pl. 21). *Proetus rowi* is distinguished from *Dechenella macrocephala,* its nearest relative in the Hamilton Group, by its more elongate, less convex, and smaller cephalon; by its less ovate glabella; by the absence of a mesial tubercle on the occipital ring; and by its somewhat less pustulose surface.

Genus Dechenella (Monodechenella) Stumm

Dechenella (Monodechenella) macrocephala (Hall)

Pl. 18, fig. 2, 3

Prostus macrocephalus Hall, 1861, p. 77. — Hall and Clarke, 1888, p.116, pl. 21, fig. 10-21; pl. 23, figs. 30, 31.
Dechenella (Monodechenella) macrocephala Harrington et al., 1959, p. 0388, fig. 297, 2.

Cranidium subquadrate, depressed convex; glabella subtriangular to subovate in outline, expands posteriorly; frontal lobe large, with two

isolated lateral lobes at postero-lateral corners; well-defined occipital furrow; occipital ring bears occipital node; border flattened, 2 mm wide at anterior margin; entire surface pustulose except border.

Pygidium semielliptical in outline, depressed convex; axial width about one-third of pygidial width; 13 axial annulations and 11 pleural annulations; border flattened, 3 mm wide at posterior, narrows anteriorly; axial ring bears mesial node and two rows of primary pustules; pleural segments bear one or two rows of primary pustules.

Measurements: length of glabella—14.5 mm; length of pygidium—20 mm; width of pygidium—30 mm.

Relationships.—In this collection, *Dechenella macrocephala* is represented by several incomplete cranidia and pygidia. However, the distinguishing features of this species, namely the subovoid glabella with its isolated lateral lobes, the border on the cephalon and pygidium, and the pustulose surface, are readily apparent on the specimens. According to Hall (1888, p. 116), pygidia with axial rows of tubercles are relatively rare; whether or not this is the common form in Pennsylvania is not certain, but both specimens of pygidia collected show these tubercles.

Dechenella macrocephala is similar to *D. curvimarginatus,* but it differs from that species in having a narrower border, a more broadly conical glabella with less distinct lateral furrow, and a more elongate pygidium that is pleurally flattened.

Order Phacopida

Family Phacopidae

Genus Phacops Emmrich

Phacops rana (Green)

Pl. 18, fig. 4-7

Calymene bufo var. *rana* Green, 1832, p. 42, casts 11, 12.

Phacops rana Hall and Clarke, 1888, p. 19, pl. 7, fig. 1-11; pl. 8, fig. 1-18; pl. 8A, fig. 21-23. — Cleland, 1903, p. 80. — Grabau and Shimer, 1910, p. 323, fig. 1638. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 329, pl. 43, fig. 8-12. — Delo, 1940, p. 22, pl. 1, fig. 1, 2. — Shimer and Shrock, 1944, p. 651, pl. 274, fig. 2-5.

Dorsal carapace subquadrate in outline, bluntly rounded anteriorly, tapers gradually toward posterior, proparian with typical phacopoid suture, micropygous.

Cephalon semicircular in outline, moderately convex; length/width ratios range from 0.48 to 0.65 for 9 specimens; genal angle acutely rounded; glabella rapidly expanding anteriorly, consists chiefly of

swollen frontal lobe which is about three-fourths of cephalic length; lateral glabellar furrows reduced to isolated pair of pits; occipital furrow reduced to shallow furrow and two isolated pits; frontal lobe rises vertically at anterior margin; cranidium, especially glabella is pustulose; librigenae small, bear schizochroal eyes separated from ocular platform by distinct furrow; eye bears from 52 to 69 facets arranged in from 9 to 11 diagonal rows; visual surface covers about 180 degrees on most specimens.

Thorax with 11 segments; axial width about one-third thoracic width; axis very convex; pleural field nearly flat adjacent to axis, bends abruptly downward in marginal half.

Pygidium subsemicircular, short, wide, with subdued segmentation; axial width less than one-third pygidial width at anterior; axis convex, tapering gradually toward back, with 7 distinct annulations and a postaxial ridge; pleural fields convex, with 5 or 6 faint annulations that lack pleural furrows; segmentation indistinct toward margins.

Measurements: length of cephalon—9.5 to 15 mm; width of cephalon—17.5 to 30 mm; length of thorax—19 mm; length of pygidium—7.5 mm; width of pygidium—14.5 mm.

Relationships.—This distinctive species is readily recognized by the semicircular outline of the cephalon, the rapidly expanding glabella with a large frontal lobe and one thin glabellar lobe, the schizochroal eyes with more or less erect visual surfaces, and the pustulose cranidium.

According to Delo (1940, p. 22) this species is often misidentified in the literature and many species of *Phacops* in the Hamilton are not *P. rana.* This species differs from *P. rana* var. *milleri* in having fewer eye facets and in having them arranged in diagonal rather than vertical rows. It differs from *P. cristata* and its varieties from the Onondaga in the complete third glabellar lobe, lack of genal spines, larger eyes, and pygidium with unfurrowed segments.

Specimens in this collection closely resemble those from New York, but commonly have more eye facets and more diagonal rows of facets. In addition, they show considerable range in such characters as cephalic outline and convexity.

Family DALMANITIDAE

Genus GREENOPS Delo

GREENOPS (GREENOPS) BOOTHI (Green)

Pl. 18, fig. 8

Cryphaeus boothi Green, 1837, p. 343, 1 text fig.

Dalmanites (Cryphaeus) boothi Hall and Clarke, 1888, p. 42, pl. 16, fig. 1-4; pl. 16A, fig. 3-8.

Cryphaeus boothi Grabau and Shimer, 1910, p. 329, fig. 1647, a, b.
Dalmanites (Cryphaeus) boothi Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 333, pl. 44, fig. 1-4.
Greenops boothi Delo, 1940, p. 88, pl. 10, fig. 14, 15, 17. — Shimer and Shrock, 1944, p. 647, pl. 274, fig. 11, 12.
Greenops (Greenops) boothi Harrington et al., 1959, p. 0480, fig. 379, 5 and 381, 1a, 1b.

Dorsal carapace subelliptical in outline, depressed convex, with thorax nearly twice as long as pygidium.

Thorax narrows gradually toward posterior, depressed convex except near margins where pleurae bend abruptly downwards; axis less than one-third thoracic width; lateral tips of pleurae flattened and separate processes; genal spine extends to fifth thoracic segment in front of pygidium, slender and pustulose on ventral side.

Pygidium semicircular to subtriangular in outline, depressed convex; length/width ratios for two specimens 0.55 and 0.57; axis about one-third pygidial width; axial rings number 7 or 8 plus post-axial ridge; five pleurae on either side of axis bear sharp, deep pleural furrows and fine interpleural furrows; marginal spines represent continuation of pleurae, 11 including terminal spine, short, flat, bluntly rounded, nearly contiguous.

Measurements: width of thorax—13 mm; length of pygidium—5.5 to 6 mm; width of pygidium—10 to 10.5 mm.

Relationships.—This species is represented in this collection by numerous impressions, both internal and external, of pygidia, and of a few incomplete thoraxes. It differs from *G. boothi* var. *calliteles* in being smaller, in having shorter, flatter, and more bluntly tipped marginal spines, and in having fewer axial rings on the pygidium. The mesial tubercle on the occipital ring, and other tubercles on axial rings, mentioned by Delo (1940, p. 88) have not been observed on these specimens.

Greenops (Greenops) boothi var. calliteles (Green)

Pl. 18, fig. 9

Cryphaeus calliteles Green, 1837, p. 346.
Dalmanites (Cryphaeus) boothi var. *calliteles* Hall and Clarke, 1888, p. 45, pl. 16, fig. 5-22; pl. 16A, fig. 9-17.
Cryphaeus boothi var. *calliteles* Grabau and Shimer, 1910, p. 330, fig. 1647, c.
Greenops boothi var. *calliteles* Delo, 1940, p. 88, pl. 10, fig. 13, 16, 19.

Cranidium with glabella that tapers toward posterior; frontal lobe about one-half of glabellar length; occipital and first glabellar furrows reduced to pits; occipital ring bears prominent mesial tubercle.

Pygidium semicircular to subtriangular in outline, depressed convex, bears 11 marginal spines; length/width ratios for 2 specimens 0.55 and 0.72; axis convex, with 7 to 10 rings plus postaxial ridge; pleural fields with 5 pleurae; pleural 5 marginal spines on either side of shorter terminal spine, slender and lanceolate, convex, all nearly of same length, posteriorly to postero-laterally directed.

Measurements: length of glabella—4.5 mm; length of pygidium—10.5 mm; width of pygidium—14.5 to 19 mm.

Relationships.—Greenops boothi var. *calliteles* differs from *Greenops boothi* in several respects, namely in the number of axial rings on the pygidium, the nature of the marginal spines, and the prominence of the mesial tubercle on the occipital ring.

Greenops boothi var. *calliteles* generally has more annulations on the pygidial axis than does *G. boothi*. Specimens referred to this variety in the present study have from 7 to 10 annulations.

Marginal spines on the pygidium of *G. boothi* var. *calliteles* are slender, separate, and convex rather than broad, crowded, and flattened as on *G. boothi*.

The mesial tubercle on the occipital ring is more prominent on *G. boothi* var. *calliteles* than on *G. boothi*. Only one cranidium of this variety has been identified in this collection, and it possesses a very pronounced mesial tubercle.

The type specimens for both *G. boothi* and *G. boothi* var. *calliteles* were collected by Green from the Hamilton in the vicinity of Huntingdon, Pennsylvania. In this area, the author has found *Greenops* only in the upper part of the Frame Shale Member. Apparently, the two forms existed side by side. Such coexistence suggests that perhaps these two morphotypes are sexual dimorphs.

Family Homalonotidae

Genus Trimerus Green

Trimerus (Dipleura) dekayi Green

Pl. 18, fig. 10, 11

Dipleura Dekayi Green, 1832, p. 79.

Homalonotus Dekayi Hall and Clarke, 1888, p. 7, pl. 2, fig. 1-11; pl. 3, fig. 1-5; pl. 4, fig. 1-6; pl. 5, fig. 1-10. — Cleland, 1903, p. 80. — Grabau and Shimer, 1910, p. 318, fig. 1631. — Prosser and Kindle, in Prosser, Kindle, and Swartz, 1913, p. 328, pl. 43, fig. 1-7.

Dipleura dekayi Shimer and Shrock, 1944, p. 643, pl. 272, fig. 26-31.
Trimerus (Dipleura) dekayi Harrington et al., 1959, p. 0460, fig. 358, 6 and 360, 5.

Cephalon subtriangular in outline, nearly twice as wide as long, moderately convex, with gonatoparian facial suture; subquadrate glabella about one-third cephalic width; occipital furrow moderately deep, continuous across cephalon; eyes small, elevated in centers of convex genae: interior covered with minute tubulipores.

Thorax unknown except for long, somewhat sinuous segments that lack trilobation and have deep trench-like pleural furrows running length of segments; interior of segments finely tubuliporous.

Pygidium unknown except for fragment of unsegmented, nonlobate, tubuliporous impression that provides some suggestion as to its very convex nature.

Relationships.—This species is represented by two incomplete cranidia, an incomplete pygidium, and innumerable thoracic segments, all of which are internal molds.

Trimerus dekayi is distinguished by its large size, subtriangular cephalon with subquadrate unsegmented glabella, and eyes elevated on convex genae. The prominent dorsal, occipital, and border furrows are also distinctive. Thoracic fragments, no matter how small and incomplete, can almost always be identified by the deep pleural furrow and the finely tubuliporous surface.

Class Crustacea
Subclass Ostracoda
Superfamily Beyrichiacea
Family Hollinidae
Genus Hollinella Coryell
Hollinella tricollina (Ulrich)

Pl. 18, fig. 12

Beyrichia tricollina Ulrich, 1891, p. 189, pl. 12, fig. 6.
Hollinella tricollina Warthin, 1937, card 79. — Stover, 1956, p. 1102, pl. 111, fig. 13.

Left plenate valve subrhomboidal to semicordate in lateral outline, length/height ratio 1.6.

Surface of valve moderately convex, quadrilobate; antiplenate lobe low, subovate; penantiplenate lobe is subspherical knob adjacent to middle of dorsal border; pair of small knobs comprise adplenate lobes; broad, flat frill measuring 0.28 mm, along free edge of valve, narrowing

toward cardinal angles; entire surface of valve finely granulose except for smooth frill.

Measurements: greatest length—1.42 mm; hinge length—1.14 mm; height—0.95 mm.

Relationships.—This species is represented in this collection by one complete external impression of a left plenate valve.

The close proximity of the two adplenate lobes adjacent to the dorsal border and the broad, flat frill serve to differentiate this species from all others of this genus.

Hollinella cf. H. sella Stover

Pl. 18, fig. 13, 14

Hollinella sella Stover, 1956, p. 1096, pl. 111, fig. 1-6.

Carapace elongate-ovate to subelliptical in lateral outline, moderately biconvex; hinge straight.

Either valve with weakly developed velate ridge paralleling adplenate and ventral borders; adplenate lobe small, isolated; antiplenate lobe prominent, subrounded knob; sulcus between carina and adplenate lobe and sulcus between lobes join and extend somewhat diminished in strength across carina to ventral border; smooth, narrow frill continuous along free edge of valve.

Relationships.—This species is represented by numerous internal molds all of which show the small, isolated, subvertical lobe and the larger, adjacent subspherical lobe that are distinctive for *H. sella.* In some specimens, however, the low ridge carina is nearly bisected into two separate lobes; the lateral outline also shows some variation in this collection.

Genus Adelphobolbina Stover

Adelphobolbina medialis Stover

Pl. 18, fig. 15

Ctenobolbina papilosa Coryell and Malkin, 1936, p. 3, fig. 6.
Adelphobolbina medialis Stover, 1956, p. 1104, pl. 112, fig. 4-9.

Left plenate valve subrhomboidal to semicordate in lateral outline; length/height ratio 1.5.

Surface trilobate; plenate lobe subovoid; median lobe comma-shaped; antiplenate lobe narrowly falcate; ventro-adplenate border with smooth frill; surface of all lobes closely and unevenly tuberculose.

Surface bisulcate; medio-adplenate sulcus deep, geniculate furrow; medio-antiplenate sulcus shallow.

Measurements: length—2 mm; height—1.3 mm.

Relationships.—According to Stover, *A. medialis* differs from *A. papillosa* in having a longer and geniculate medio-adplenate sulcus and a shorter frill that is produced antiplenately into a short spur. The same sulcus and the tuberculate surface distinguish *A. medialis* from *A. megalia.*

Only one external mold of this species has been collected, but several internal molds are also questionably referred to it. Features of the external mold are nearly identical with those of the species illustrated by Stover except that the tubercles appear to be somewhat coarser in the New York specimens.

Except for the pits in the summits of the tubercles present on *C. longisulcata* (Swartz and Oriel) and absent on *A. medialis,* the two species appear to be conspecific. Inasmuch as *Ctenobolbina longisulcata* Swartz and Oriel (1948) is based on a single incomplete specimen, the writer prefers to refer the Pennsylvania specimens to *A. medialis,* with *C. longisulcata* as a synonym.

Genus Ctenoloculina Bassler

Ctenoloculina cicatricosa (Warthin)

Pl. 18, fig. 16-18

Tetradella cicatricosa Warthin, 1934, p. 209, pl. 1, fig. 4-6.
Ctenoloculina cicatricosa Bassler, 1941, p. 22.
Ctenoloculina acanthopora Swartz and Oriel, 1948, p. 553, pl. 79, fig. 8-14.
Ctenoloculina cicatricosa Kesling and Weiss, 1953, p. 44, pl. 2, fig. 9-14; pl. 3, fig. 1. — Stover, 1956, p. 1105, pl. 112, fig. 15, 16.

Shell elongate subelliptical in lateral outlines; length/height ratio about 1.6.

Surface quadrilobate with lobes extending nearly height of valve; L1, L2, L3 ventrally extended beyond border of shell to form spurs; surface of lobes slightly convex to flattened; L4 finely reticulate; L3 reticulate and papillose.

Surface trisulcate; very thin rims neatly outline all sulci.

Female carapace with at least 6 adplenate, subspherical loculi recessed along central margin.

Relationships.—Specimens in this collection are nearly identical with illustrations of *C. acanthopora* (Swartz and Oriel, 1948), and *C. cicatricosa* (Kesling, 1952 and Stover, 1956). The spinules of *C. acanthopora* were not observed, but L3 is papillose in the ventral portion, and reticulate in the dorsal portion, and L4 is completely reticulate. The reticulate

surface of L4 and the papillose surface of L3 are features of *C. acanthopora,* whereas Kesling's *C. cicatricosa* is completely papillose, and *Tetradilla cicatricosa* (Warthin) is papillose except for smooth L1 on female carapaces. *Ctenoloculina acanthopora* might better be relegated to a subspecific rank, in that its characters are so nearly identical with those of *C. cicatricosa.*

Genus Ulrichia Jones

Ulrichia spinifera Coryell and Malkin?

Pl. 19, fig. 1, 2

Ulrichia spinifera Coryell and Malkin, 1936, p. 1, 2, fig. 1, 2. — Kesling, 1952, p. 27, pl. 4, fig. 9-12. — Kesling and Weiss, 1953, p. 19, pl. 3, fig. 32-35. — Stover, 1956, p. 1109, pl. 113, fig. 14-17.

Right plenate valve subelliptical in lateral outline; length/height ratio 1.7; valve depressed convex with two small, suberect nodes in dorsal third of valve and at position one-third and two-thirds distance behind adplenate cardinal corner; free edge with narrow, rounded velate ridge.

Surface reticulate except for velate ridge and nodes.

Measurements: length—8 mm; height—5 mm.

Relationships.—This species is represented by one nearly complete external mold of a right plenate valve, and numerous fragmentary specimens.

The description applies to the external mold. Comparisons with *U. ventura* Stover (1956), *U. acricula* Kesling (1952), and *U. spinifera* Coryell and Malkin (1936) indicate that this specimen most closely resembles *U. spinifera* in the following characters: somewhat more distantly spaced and subvertical nodes; velate ridge narrower than that of *U. acricula;* reticulate surface not as fine as that of *U. ventura;* ventral margin subparallel with hinge. It is almost identical with *U. spinifera* as illustrated by Coryell and Malkin (1936, fig. 2).

Family Beyrichiidae

Genus Hibbardia Kesling

Hibbardia lacrimosa (Swartz and Oriel)

Pl. 19, fig. 3, 4

Amphissites lacrimosa Swartz and Oriel, 1948, p. 553, pl. 79, fig. 15.
Hibbardia lacrimosa Kesling, 1953, p. 19, pl. 8, 9. — Stover, 1956, p. 1112, pl. 115, fig. 1, 2.

Left plenate valve subsemielliptical in lateral outline, very convex; length/height ratio 1.5; thin, marginal rim continuous along free margin.

Surface of valve bilobate and unisulcate with shallow arcuate sulcus; sulcus deepest at middle of valve, marked by teardrop-shaped pit; surface reticulate with pits arranged more or less concentrically around median pit.

Measurements: length—1.9 mm; height—1.3 mm; length of adplenate lobe—1 mm.

Relationships.—This species is represented in this collection by an internal and external mold of one left plenate valve, and numerous fragmentary specimens.

Hibbardia lacrimosa is distinguished from *H. subquadratus* (Ulrich) by its more fully rounded lateral outline and its reticulate surface with the medial dacryoid (teardrop-shaped) pit.

Superfamily Cypridacea

Family Cytherellidae

Genus Ponderodictya Coryell and Malkin

Ponderodictya punctulifera (Hall)

Pl. 19, fig. 5, 6

Leparditia punctulifera Hall, 1860, p. 92.
Ponderodictya bispinulata Coryell and Malkin, p. 16, fig. 28, 28a, 29, 30.
Hamiltonella punctulifera Stewart, 1936, p. 759, pl. 102, fig. 1-5.
Ponderodictya punctulifera Kesling and Weiss, 1953, p. 66, pl. 5, fig. 21-29. — Stover, 1956, p. 1117, pl. 114, fig. 20.

Carapace elongate-reniform with left valve larger and overlapping right valve on all but particularly on the ventral margin.

Left valve elongate-reniform in lateral outline, moderately convex; length/height ratio 1.7.

Surface unilobate, evenly and moderately convex; two short spurs in front of posterior border; surface is coarsely and rather irregularly reticulate.

Measurements: length—2.4 mm; height—1.4 mm.

Relationships.—According to Kesling and Weiss (1953, p. 66), this species includes several different types that differ somewhat from one another in the character of the spurs, ridges, and nodes, in the surface texture, and in the shape of the valves. However, it is generally characterized by its subreniform outline and reticulate surface with two posterior spurs. It resembles the Onondaga-Marcellus species *Favulella favulosa* (Jones), but that species has a marginal border lacking reticulation.

Family Thlipsuridae

Genus Octonaria Jones

Octonaria bifurcata Stover

Pl. 19, fig. 7

Octonaria bifurcata Stover, 1956, p. 1118, pl. 115, fig. 7-9.

Left valve subovate to subelliptical in lateral outline; moderately to very convex; convexity increases abruptly in anterior fifth of valve; narrow antero-ventral marginal flange present on internal mold of valve.

Surface convex with three more or less longitudinally disposed, somewhat irregular furrows in posterior two-thirds of valve; dorsal furrow slightly arcuate, transversely subdivided by several weak crossbars; ventral furrow U-shaped, beginning immediately behind medial furrow, continuing to posterior portions of dorsal and medial furrows, transversely subdivided by several weak crossbars; medial furrow nearly straight, shorter than other two furrows, beginning immediately behind dorsal furrow and extending into the bight of the ventral furrow; furrows separated by a dorsal ridge that bifurcates posteriorly, and by a ventral ridge.

Relationships.—This species is represented by one internal mold of a left valve. Stover erected the species for specimens of *Octonaria* that possess the three furrows separated by a dorsal and a ventral ridge; the dorsal ridge bifurcating posteriorly to separate the dorsal and ventral furrows, and to separate the medial and ventral furrows. Subdivisional crossbars are generally present in furrows.

Family Quasillitidae

Genus Quasillites Coryell and Malkin

Quasillites sp.

Pl. 19, fig. 8

Carapace elongate-elliptical to subrhomboidal in lateral outline; length/height ratio approximately 2; greatest height near middle of carapace; anterior end with spur.

Surface of valve regularly convex except at posterior; arcuate ridge paralleling posterior border; short ventral spur near anterior border; surface except for posterior ridge and median spot almost completely covered by very fine pits linearly arranged; rows of pits separated by fine, low ridges which curve more or less concentrically with valve borders in posterior half of valve.

Measurements: length—0.78 and 0.99 mm; height—0.42 and 0.44 mm.

Relationships.—These specimens most nearly resemble *Quasillites angulatus* as described and illustrated by Stover (1956, p. 1124) and *Quasillites* cf. *Q. lobatus* illustrated by Swartz and Oriel (1948, pl. 80, fig. 19). Stover has indicated that these are the same species and belong together in *Q. angulatus* Smith. Smith, however, has plainly stated that a primary difference between *Q. angulatus* and *Q. lobatus* is the relative position of the greatest height, being definitely anterior in *Q. angulatus*. Figure 19, plate 80 of Swartz and Oriel shows a nearly medial position of greatest height, as well as much finer surface ornament than that of *Q. andulatus*. This is attributed to infraspecific variation by Stover. The several external molds of *Quasillites* in this collection exhibit rather fine surface ornament that is disposed in a whorl-like pattern posteriorly.

Genus Bufina Coryell and Malkin

Bufina bicornuta (Ulrich)

Pl. 19, fig. 9

Moorea bicornuta Ulrich, 1891, p. 191, pl. 16, fig. 4a-c. — Brabau, 1898, p. 310, fig. 253.

Bufina bicornuta Warthin, 1937-1945, card no. 71 — Stover, 1956, p. 1126, pl. 118, fig. 1-5.

Left plenate valve subelliptical in outline; greatest length somewhat above middle of valve; length/height ratio about 2.

Surface faintly bilobate, bears shallow median sulcus; two blunt spines vertically aligned, at plenate end, adplenately directed; crescentic ridge adjacent to antiplenate border; small arcuate depression immediately inside crescentic ridge; surface texture more or less smooth.

Measurements: length—0.97 mm; plenate height—0.50 mm; antiplenate height—0.44 mm.

Relationships.—This species is represented in this collection by two external impressions of left plenate valves. *Bufina* is distinguished by its subelliptical lateral outline, and by its surface with two adplenate spurs and a crescentic antiplenate ridge. This species differs from *B. elongata* in the more median position of its greatest height.

Genus Euglyphella Warthin

Euglyphella numismoides Swartz and Oriel

Pl. 19, fig. 10, 11

Euglyphella numismoides Swartz and Oriel, 1948, p. 562, pl. 81, fig. 1-8. — Stover, 1956, p. 1131, pl. 118, fig. 24-27, text-fig. 7, 8.

Right plenate valve depressed convex, elongate-subovate in outline; greatest length about midway between dorsal and ventral borders; length/height ratio 2.2.

Surface bears two prominent longitudinal furrows; outer furrow more or less J-shaped, with dorsal limb and adplenate hook, interrupted dorsoplenately by narrow crossbar at which position the furrow continues to dorsal border; inner furrow nearly straight, slightly inclined antiplenately, separated from outer furrow by prominent inner ridge, divided by narrow crossbar into a furrow and a pit; pit lies near middle of valve; plenate and bears flat subtriangular flange.

Measurements: length—0.92 mm; plenate height—0.44 mm; antiplenate height—0.27 mm; thickness—0.17 mm.

Relationships.—Euglyphella numismoides is represented in this collection by one complete external impression of a right plenate valve, and several other incomplete external molds.

The antiplenate end of the single complete specimen is not well preserved, so the spinosa process in that position mentioned by Swartz and Oriel (1948, p. 562) as a feature which differentiates this species from *E. sigmoidalis* (Warthin) has not been observed. However, this species may be distinguished from *E. sigmoidalis* by the narrow crossbars interrupting the dorsal limb of the outer furrow and interrupting the inner furrow. The ventral crossbar through the outer furrow has not been observed on specimens in this collection.

Subclass Branchiopoda

Genus Schizodiscus Clarke

Schizodiscus capsa Clarke

Pl. 19, fig. 12

Schizodiscus capsa Clarke, in Hall and Clarke, 1888, p. 207, pl. 35, fig. 1-9. —Grabau and Shimer, 1910, p. 332. — Shimer and Shrock, 1944, p. 660, pl. 279, fig. 7-9.

Carapace small, subsemicircular to subsemiovate in outline; valves nearly flat to depressed convex; margins regularly rounded, dorsally truncate; hinge line dorsal, straight, equals greatest length, with right valve apparently hinging within left valve; beak at hinge line, one-third of valve length behind anterior margin; umbonal ridge inclined about 30° from hinge line, more distinct near beak, less clearly defined toward postero-ventral margin.

Surface bears widely spaced concentric undulations and fine concentric striae; striae spaced about 8 per 1 mm beak, spaced 4 per 1 mm near posterior margin.

Measurements: length right valve—5.3 mm; width right valve—2.7 mm; convexity right valve—0.4 mm.

Relationships.—Schizodiscus capsa is characterized by its small size, semiovate outline, anterior beaks, and concentric ornament. Its nearest relatives, the estherids, differ primarily in having shorter hinge lines terminated anteriorly by the beaks. Unlike Clarke's specimens (1888, pl. 35, fig. 1-9), this specimen resembles the estherids in having an umbonal ridge.

Phylum ECHINODERMATA

Class CRINOIDEA

Genus TECHNOCRINUS

TECHNOCRINUS? sp.

Pl. 19, fig. 13, 14

Relationships.—Specimens tentatively identified as *Technocrinus* include internal molds and external casts of portions of calices. Inasmuch as the specimens are incomplete, it is difficult to determine the number of brachial and infrabasal plates which are characteristic for this genus. However, the general disposition of calical plates, i.e. each row of plates apparently offset from the rows of plates above and below, is somewhat distinctive for this genus.

SELECTED BIBLIOGRAPHY

Ashley, G. H. and others, (1933), *Classification and nomenclature of rock units,* Geol. Soc. America Bull., v. 44, p. 423-459.

Bassler, R. S. (1941), *Ostracoda from the Devonian (Onondago) chert of western Tennessee,* Jour. Washington Acad. Sci., v. 31, no. 1, p. 21-27, 1 pl.

———— (1953), *Bryozoa,* Geol. Soc. America Treatise on Invert. Paleont., pt. G, 253 p.

Bayer, Frederick M. and others (1956), *Coelenterata,* Geol. Soc. America Treatise on Invert. Paleont., pt. F, 498 p.

Beecher, C. E. (1890) *North American species of Strophalosia,* Am. Jour. Sci., ser. 3, v. 40, p. 240-246.

———— (1891), *Development of the Brachiopoda,* Am. Jour. Sci., ser. 3, v. 41, 343-357; v. 44, p. 133-155.

Bublichenko, N. L. (1956), *Some new representatives of Devonian and Carboniferous brachiopoda from Rudny-Altai and Sary-Arka,* Investia Akad. Nauk Kazakhoskoi SSR, Serv. Vyp. 23, p. 93-104.

Castelnau, Francis de (1843), *Essai sur le systeme silurien da l'Amerique septentrionale,* 56 p.

Caster, K. E. (1939), *A Devonian fauna from Columbia,* Bull. American Paleont., v. 24, no. 83, 218 p.

Clarke, J. M., and Ruedemann, R. (1903), *Catalogue of type specimens of Paleozoic fossils in New York State Museum,* New York State Mus. Bull. 65, 847 p.

Claypole, E. W. (1855), *Preliminary report on the paleontology of Perry County,* Pennsylvania 2nd Geol. Survey Rept. F2, 437 p.

Cleland, Herdman F. (1903), *A study of the fauna of the Hamilton formation of the Cayuga Lake section in central New York,* U. S. Geol. Survey Bull. 206, 112 p.

Cloud, Preston E., Jr. (1942), *Terebratuloid Brachiopoda of the Silurian and Devonian,* Geol. Soc. America Spec. Paper 38, 182 p., 26 pls.

Conrad, T. A. (1838), *Report on the paleontological department of the survey,* New York State Geol. Survey Ann. Rept. 2, p. 107-119.

———— (1839), *Report on the paleontological department of the survey,* New York State Geol. Survey Ann. Rept. 3, p. 57-66.

———— (1841), *Report on the paleontology of the State of New York,* New York State Geol. Survey Ann. Rept. 5, p. 25-57.

———— (1842), *Observations on the Silurian and Devonian systems of the United States, with descriptions of new organic remains,* Jour. Acad. Nat. Sci. Phila., v. 8, p. 228-280.

Cooper, G. A. (1930), *Stratigraphy of the Hamilton group of New York,* Am. Jour. Sci., ser. 5, v. 19, p. 116-124 (part 1); p. 214-236 (part 2).

———— (1933), *Stratigraphy of the Hamilton group of eastern New York,* Am. Jour. Sci., ser. 5, v. 26, p. 537-551.

———— and Williams, J. S. (1935), *Tully formation of New York,* Geol. Soc. America Bull., v 46, no. 5, p. 781-868, 7 pls.

———— and others (1942), *Correlation of the Devonian sedimentary formations of North America,* Geol. Soc. America Bull., v. 53, p. 1729-1794.

———— (1942), *New genera of North American brachiopods,* Jour. Washington Acad. Sci. v. 32, no. 8, p. 228-235.

———— (1957), *Paleoecology of Middle Devonian of eastern and central United States,* Geol. Soc. America Mem. 67, p. 249-277.

Coryell, N. N. and Malkin, T. S. (1936), *Some Hamilton ostracodes from Arkona, Ontario,* Am. Mus. Novitates, no. 891, p. 1-20.

Degens, Egon T. (1957), *Geochemistry of sedimentary rocks,* unpublished syllabus for course of same name, at Pennsylvania State Univ., 60 p.

————, Williams, E. G., and Keith, M. L. (1958). *Environment studies of Carboniferous sediments,* Part II: *Application of geochemical criteria,* Am. Assoc. Petroleum Geologists Bull. v. 42, p. 981-997.

Delo, David M. (1940), *Phacopid trilobites of North America,* Geol. Soc. America, Spec. Paper 29, 135 p., 13 pls.

D'Invilliers, E. V. (1891), *Report on the geology of the four counties Union, Snyder, Mifflin, and Juniata,* Pennsylvania 2nd Geol. Survey Rept. F3, 420 p.

Eaton, Amos (1831), *Geological equivalents,* Am. Jour. Sci., ser. 1, v. 21, p. 132-138.

———— (1832), *Geology textbook,* 2nd ed.

Elias, M. K., and Condra, C. E. (1957), *Fenestella from the Permian of West Texas,* Geol. Soc. America Mem. 70, 158 p.

Fettke, C. R. (1933), *Subsurface Devonian and Silurian sections across northern Pennsylvania and southern New York,* Geol. Soc. America Bull., v. 44, p. 601-660.

Grabau, A. W., and Shimer, H. W. (1909), *North American index to fossils*, v. 1, A. G. Seiler and Co., New York, 853 p.

———— and Shimer, H. W. (1910), *North American index fossils*, v. 2, A. G. Seiler and Co., New York, 909 p.

———— (1917), *Stratigraphic relationships of the Tully limestone and the Genessee shale in North America*, Geol. Soc. America Bull., v. 28, p. 945-958.

———— (1924), *Principles of stratigraphy*, A. G. Seiler and Co., New York, 1185 p.

Green, Jacob (1832), *A monography of the trilobites of North America*, Philadelphia, 93 p.

———— (1837), *Description of several new trilobites*, Am. Jour. Sci. ser. 1, v. 32, p. 343-349.

———— (1838), *Description of new trilobite (Calymene rowii, New York)*, Am. Jour. Sci., ser. 1, v. 33, p. 406-407.

Hall, James (1843), *Geology of New York, Part IV, comprising the survey of the fourth geological district*, 683 p.

———— (1852), *Descriptions of the organic remains of the lower middle division of the New York system*, New York State Geol. Survey, Paleont., v. 2, 362 p.

———— (1857), *Descriptions of Paleozoic fossils*, New York State Cab. Ann. Rept. 10, p. 39-180.

———— (1859), *Catalogue of the species of fossils of New York*, New York State Cab. Ann. Rept. 12, p. 63-96.

———— (1860), *Descriptions of new species of fossils, from the Hamilton group of western New York, with notices of others from the same horizon in Iowa and Indiana*, New York State Cab. Ann. Rept. 13, p. 76-94.

———— (1861), *Descriptions of new species of fossils from the Upper Helderberg, Hamilton, and Chemung groups*, New York State Cab. Ann. Rept. 15, p. 29-80.

———— (1863), *Descriptions of new species of Brachiopoda from the Upper Helderberg, Hamilton, and Chemung groups*, New York State Cab. Ann. Rept. 16, p. 19-37.

———— (1867), *Descriptions and figures of the fossil Brachiopoda of the Upper Helderberg, Hamilton, Portage, and Chemung groups*, New York State Geol. Survey, Paleont., v. 4, 428 p., 63 pls.

———— (1870), *Preliminary notice Lamellibranchiata, 2*. Unable to determine source.

———— and Whitfield, R. P. (1872), *Descriptions of new species of fossils from the vicinity of Louisville, Kentucky, and the Falls of the Ohio*, New York State Mus. Ann. Rept. 24, p. 181-200.

———— (1876), *Illustrations of Devonian fossils; Gasteropoda, Pteropoda, Cephalopoda, Crustacea, and Corals of the Upper Helderberg, Hamilton, and Chemung groups*, New York State Geol. Survey, Paleont.

———— (1879a), *Corals and bryozoans of the Lower Helderberg group*, New York State Mus. Ann. Rept. 32, p. 141-176.

———— (1879b), *Descriptions of the Gastropoda, Pteropoda, and Cephalopoda of the Upper Helderberg, Hamilton, Portage, and Chemung groups, New York*, New York State Geol. Survey, Paleont., v. 5, pt. 2, 492 p., 93 pls. (in separate volume).

Hall, James (1881), *Bryozoans of the Upper Helderberg and Hamilton groups,* Albany Inst. Trans., v. 10, p. 145-197.

——— (1883), *Lamellibranchiata I. Plates and explanations. Monomyaria of the Upper Helderberg, Hamilton, and Chemung groups,* New York State Geol. Survey, Paleont., v. 5, pt. 1 (advance copy).

——— (1884), *Lamellibranchiata I. Descriptions and figures of the Monomyaria of the Upper Helderberg, Hamilton, and Chemung groups,* New York State Geol. Survey, Paleont., v. 5, pt. 1, 268 p., pls. 1-33, 81-92.

——— (1885), *Lamellibranchiata II. Descriptions and figures of the Dimyaria of the Upper Helderberg, Hamilton, and Chemung groups,* New York State Geol. Survey, Paleont., v. 5, pt. 1, 562 p., pls. 34-80, 93-96.

——— (1886), *Illustrations with explanations of Upper Helderberg fossils,* New York State Geologist Ann. Rept. 5.

——— and Simpson, G. B. (1887), *Corals and Bryozoa; descriptions and figures of species from the Lower Helderberg, Upper Helderberg, and Hamilton groups,* New York State Geol. Survey, Paleont., v. 6, 298 p., 66 pls.

——— and Clarke, J. M. (1888), *Descriptions of the trilobites and other Crustacea of the Oriskany, Upper Helderberg, Hamilton, Portage, Chemung, and Catskill groups,* New York State Geol. Survey, Paleont., v. 7, 236 p. 36 pls.

——— and Clarke, J. M. (1892), *An introduction to the study of the genera of Paleozoic Brachiopoda,* New York State Geol. Survey, Paleont., v. 8, pt. 1, 367 p.

——— and Clarke, J. M. (1893), *An introduction to the study of the genera of Paleozoic Brachiopoda,* New York State Geol. Survey, Paleont., v. 8, pt. 2, 394 p., 63 pls.

Harrington, N. J. and others (1959), *Trilobita,* Geol. Soc. America Treatise on Invert. Paleont., pt. 0, Arthropoda 1, p. 038-0540.

Imbrie, John (1959), *Brachiopods of the Traverse Group (Devonian) of Michigan, Part I,* Am. Mus. Nat. Hist. Bull. u166, art. 4, p. 345-410.

Kesling, R. V. (1951), *Terminology of ostracod carapaces,* Univ. Michigan, Contrib. Mus. Paleont., v. 9, no. 4, p. 93-171, pls. 1-18.

——— (1952a), *A study of Ctenoloculina cicatricosa (Warthin).* Univ. Michigan Contrib. Mus. Paleont., v. 9, no. 8, p. 247-290, pls. 1-3.

———1952b), *Ostracods from the families Leperditellidae, Primitiidae, Drepanellidae, Aechminidae and Kirbyidae from the Middle Devonian Bell shale of Michigan,* Univ. Michigan, Contrib. Mus. Paleont., v. 10, no. 2, p. 21-44, pls. 1-5.

——— (1953), *A beyrichiid ostracod from the Middle Devonian Wanakah shale,* Buffalo Soc. Nat. Sci. Bull., v. 21, no. 2, p. 19-24, pls. 8, 9.

——— and Weiss, M. (1953), *Ostracods from the Norway Point formation of Michigan,* Univ. Michigan, Contrib. Mus. Paleont., v. 11, no. 3, p. 33-76, pls. 1-5.

Kindle, E. M. (1912), *The Onondaga fauna of the Allegheny region,* U. S. Geol. Survey Bull. 508, 144 p., 13 pls.

Knight, J. Brookes (1941), *Paleozoic gastropod genotypes,* Geol. Soc. America Spec. Paper 32, 509 p., 96 pls.

——— (1942), *Four new genera of Paleozoic Gastropoda,* Jour. Paleont., v. 16, p. 487-488.

——— (1945), *Some new genera of Bellerophontacea,* Jour. Paleont., v. 19, p. 333-340.

Krynine, Paul D. (1948), *The megascopic study and field classification of sedimentary rocks*, Jour. Geol., v. 56, p. 130-165.

Lesley, J. P. (1889), *A dictionary of the fossils of Pennsylvania and neighboring states*, Pennsylvania 2nd. Geol. Survey Rept. P4, 1283 p. (in 3 volumes).

———— (1892), *Summary description of the geology of Pennsylvania*, Pennsylvania 2nd Geol. Survey Final Rept., v. 2, p. 721-1628.

Linnaeus, Carolus (1767), *Systema Naturae per regua tria naturae, secuudum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, loci*, Edition 12.

Longwell, C. R. and others (1949), *Sedimentary facies in geologic history*, Geol. Soc. America Mem. 39, 171 p.

McNair, A. H. (1942), *Upper Devonian Bryozoa*, Jour. Paleont., v. 16, p. 343-350, pls. 45-49.

Miller, S. A. (1877), *The American Paleozoic Fossils*, published by the author, Cincinnati, Ohio, 253 p.

Moore, R. C. (1954), *Evolution of late Paleozoic invertebrates in response to major oscillations of shallow seas*, Bull. Mus. Comparative Zoology, v. 112, no. 3, p. 259-286.

Muir-Wood, H. (1962), *On the morphology and classification of the Brachiopod Suborder Chonetoidea*, British Mus. (Nat. Hist.), 132 p., 16 pl.

Nicholson, N. A. (1874), *Descriptions of new fossils from the Devonian formation of Canada*, Geol. Mag., new ser., decade 2, v. I, p. 117-126, pl. 6.

Prosser, C. S. (1912), *Devonian and Mississippian formations of northeastern Ohio*, Ohio Geol. Survey Bull. 15, 574 p.

———— (1888), *Upper Hamilton of Chenango and Otsego Counties, New York (abst.)*, Am. Assoc. Adv. Sci. Proc. 36, p. 210.

————, Kindle, E. M., and Swartz, G. K. (1913), *Middle Devonian deposits of Maryland*, Maryland Geol. Survey, Middle and Upper Devonian, p. 23-114.

———— and Kindle, E. M. (1913), *Systematic Paleontology of the Middle Devonian deposits of Maryland; Brachiopoda, Pelecypoda, Gastropoda, Trilobita*, Maryland Geol. Survey, Middle and Upper Devonian, p. 124-335, 37 pls.

Rogers, H. D. (1858), *The geology of Pennsylvania, a government survey*, v. 1, 586 p.; v. 2, 1046 p.

Saemann, L. (1852), *Ueber die Nautiliden*, Paleontographica, Beitrage zur Naturgeschichte der Vorwelt, Dritter Band, Dritter Lieferung, p. 121-167, plates.

Schuchert, Charles (1897), *A synopsis of American fossil Brachiopoda*, U. S. Geol. Survey Bull. 87, 464 p.

———— and Levene, C. M. (1929), *Fossilium Catalogue, in Brachiopoda*, pars 42, W. Junk, Berlin, 140 p.

Shimer, H. W. and Shrock, R. R. (1944), *Index fossils of North America*, John Wiley and Sons, New York, 837 p., 303 pls.

Simpson, George B. (1895), *A handbook of the genera of the North American Paleozoic Bryozoa*, New York State Geologist Ann. Rept. 14, p. 407-669, 24 pls.

Smith, M. L. (1956), *Some ostracods from the Middle Devonian Ledyard and Wanakah members of the Ludlowville formation in western New York*, Jour. Paleont., v. 30, p. 1-8, pl. 1.

Stauffer, C. R. (1909), *The Middle Devonian of Ohio,* Ohio Geol. Survey Bull. 10, 204 p.

Stevenson, J. J. (1882), *Geology of Bedford and Fulton Counties,* Pennsylvania 2nd Geol. Survey Rept. T2, 382 p.

Stewart, Grace A. (1927), *Fauna of the Silica shale of Lucas County,* Geol. Survey Ohio Bull. 32, 76 p., 5 pls.

———— (1936), *Ostracodes of the Silica shale, Middle Devonian, of Ohio,* Jour. Paleont., v. 10, p. 739-763, pls. 100-102.

Stover, Lewis (1956), *Ostracoda from the Windom shale (Hamilton) of western New York,* Jour. Paleont., v. 30, no. 5, p. 1092-1142, pls. 111-119.

Stumm, Erwin, C. (1942), *Fauna and stratigraphic relations of the Prout limestone and Plum Brook shale of northern Ohio,* Jour. Paleont., v. 16, p. 549-562.

———— (1949), *Revision of the families and genera of the Devonian tetracorals,* Geol. Soc. America Mem. 40, 92 p.

———— 1950), *Type invertebrate fossils of North America (Devonian),* Div. I, Part C, Wagner Free Inst. Sci., Phila.

Swartz, F. M. and Swain, F. M. (1941), *Ostracoda from the Middle Devonian Onondaga beds of central Pennsylvania,* Geol. Soc. America Bull., v. 52, p. 381-458, pls. 1-8.

———— and Oriel, S. S. (1948), *Ostracoda from the Middle Devonian Windom beds in western New York,* Jour. Paleont., v. 22, p. 541-566, pls. 79-81.

Twenhofel, William H. (1926), *Treatise on sedimentation,* Williams and Wilkins Co., Baltimore, 661 p.

Ulrich, E. O. (1891), *New and little known American Paleozoic Ostracoda,* Cincinnati Soc. Nat. Hist., Jour., v. 13, p. 173-211, pls. 7-19.

Vanuxem, Lardner (1840), *Report of the geological survey of the third district,* New York Geol. Survey Ann. Rept. 4, p. 355-383.

———— (1842), *Geology of New York. Part III, comprising the survey of the third geological district,* 306 p.

Warthin, A. S., Jr. (1934), *Common Ostracoda of the Traverse group,* Univ. Michigan, Contrib. Mus. Paleont., v. 4, no. 12, p. 205-226, 1 pl.

———— (1937-1945), *Type invertebrate fossils of North America (Devonian), Ostracoda,* Wagner Free Inst. Sci., cards.

Weller, Stuart (1914), *Mississippian Brachiopoda of the Mississippi Valley Basin,* Illinois Geol. Survey Monograph 1, 508 p., 83 pls. (in separate volume).

White, I. C. (1883), *Geology of the Susquehanna River region,* Pennsylvania 2nd Geol. Survey Rept. G7, 464 p.

———— (1885), *Geology of Huntingdon County,* Pennsylvania 2nd Geol. Survey Rept. T3, 471 p.

Whitefield, R. P. (1893), *Contributions to the paleontology of Ohio,* Geol. Survey Ohio Rept., p. 407-494, pls. 1-12.

Willard, Bradford (1935a), *Hamilton group of central Pennsylvania,* Geol. Soc. America Bull., v. 46, p. 195-224.

———— (1935b), *Portage group in Pennsylvania,* Geol. Soc. America Bull., v. 46, p. 1195-1218.

Willard, Bradford (1935c), *Hamilton group along the Allegheny Front, Pennsylvania,* Geol. Soc. America Bull., v. 46, p. 1275-1290.

——— (1937), *Tully limestone and fauna in Pennsylvania,* Geol. Soc. America Bull., v. 48, no. 9, p. 1237-1256, 2 pls.

——— and Cleaves, A. B. (1933), *Hamilton group of eastern Pennsylvania,* Geol. Soc. America Bull., v. 44, p. 757-782.

———, Swartz, F. M., and Cleaves, A. B. (1939), *Devonian of Pennsylvania* Pennsylvania Geol. Survey, 4th ser., Bull. G19, 481 p., 40 pls.

Williams, Alwyn (1953), *North American and European Strophеodontids; their morphology and systematics,* Geol. Soc. America Mem. 56, 67 p., 13 pls.

Williams, M. S. (1890), *The Cuboides zone and its fauna; a discussion of methods of correlation,* Geol. Soc. America Bull., v. 1, p. 481-500.

——— (1903), *The correlation of geological faunas,* U. S. Geol. Survey Bull. 210, 147 p.

——— and Kindle, E. M. (1905), *Contributions to Devonian paleontology,* U. S. Geol. Survey Bull. 244, 144 p.

APPENDIX—DESCRIPTION OF THE SECTIONS

INTRODUCTION

Descriptions of eighteen of the most complete sections of the Mahantango Formation examined in south-central Pennsylvania have been included in the present study. The locations of these sections are shown in figure 1. Several other sections, some very short, also were measured and described to provide additional information about particular features of the formation in certain areas.

The sections were measured by one or more of the three following methods: (1) traversing with a 100-foot tape, then computing the thickness; (2) measuring the thickness directly with a 6-foot folding rule; and (3) plane table mapping. Repeating the measurements in a few sections suggests that the range of error is on the order of plus or minus 5 feet per 100 feet thickness.

All accessible parts of each section were examined for fossils, and collecting was done at each fossiliferous level until no new species were found. If fossils were collected from talus only, a range in thickness was noted for that material. Relative abundance of fossil species was described on the basis of the number of specimens collected, as follows: present, if one specimen was collected; common, if 2 to 10 specimens were collected; abundant, if more than 10 specimens were collected; and very abundant, if samples were extremely rich in a given species. Most fossils of the Mahantango Formation are external and internal molds which lend themselves well to paleontologic study if the sediment is fine-grained.

SECTIONS IN PERRY AND ADJACENT COUNTIES

Section 1.—Section at Rockville

Three quarries that are situated in the gap through Little Mountain on the eastern side of the Susquehanna River, north of Rockville, Pa. provide excellent exposures of the Montebello Member of the Mahantango Formation. These quarries are referred to as the northern, middle, and southern quarries; the southern quarry in which the power station is now located, is 850 feet east of the railroad crossing along the secondary road leading into the narrow valley between Little Mountain and Blue Mountain.

On the Harrisburg, Pa. Quadrangle, the base of the section, in the southern quarry, is 1300 feet north of lat. 40°20′N. and 4200 feet east of long. 76°55′W.

At Rockville, the Montebello Member is nearly completely exposed, and most of the lower shale member is exposed, but the upper shale member is concealed. The upper contact of the Mahantango Formation with the Harrell Formation and the lower contact of the Mahantango Formation with the Marcellus Formation are not exposed. Approximately 20 percent of the section as described is concealed.

Briefly, the described units and their locations in this section are as follows: units 1 to 9 in the northern quarry; units 10 to 14 along the road between the northern and middle quarries; unit 15 in the middle quarry; unit 16 and the upper part of unit 17 along the road between the middle and southern quarries; and units 17 to 21 in the southern quarry.

Numerous low angle faults transect the section at Rockville, as well as the section at Marysville (see Cloos and Broedel, 1943), but the displacements of the faults generally offset one another, and it has been assumed here that the thickness measurements have not been significantly affected.

The upper limit of the *Mediospirifer*-coralline Assemblage Zone is placed, with reservation, at 595 feet, in unit 9. The *Paraspirifer acuminatus* Zone may be represented here by the fossiliferous sequence from 246 to 250 feet, in unit 15.

Harrell Formation
Covered

Hamilton Group

Mahantango Formation
Upper shale member
Covered

Montebello Member

Unit		*Unit Thickness*	*Cumulative Thickness*
1.	Sandstone, fine-grained and siltstone, light olive gray (5Y5/2), weathering dark yellowish brown (10YR4/2), in 3- to 12-inch cross-beds. Crinoid columnals and organic fragments in upper part. Thickness 22 feet. Siltstone, dark gray (N3), weathering olive gray (5Y4/1), commonly in 6-inch cross-beds. Sandstone, fine-grained, grayish red (5R4/2), weathering light olive gray, in 4- to 18-inch cross-beds forms 40 percent of siltstone subunit. Interbeds of shale form less than 5 percent. Thin bed of hematitic sandstone present. Thickness 25 feet. Sandstone, medium-grained, light olive gray,		

Unit		Unit Thickness	Cumulative Thickness
	weathering pinkish gray, in 1- to 2-foot undulose beds. Thickness 12 feet. Fossiliferous zones as noted: 19 feet from top (899 feet)—Brachiopoda: *Camarotoechia congregata* (C), *Athyris spiriferoides*? (P), *"Spirifer"* sp. (P). 22½ feet from top (895.5 feet)—*Tropidoleptus carinatus* (A), *Devonochonetes syrtalis* (P), *Retichonetes vicinus*? (P), *Camarotoechia congregata*? (A), *C. prolifica* (C), *Mediospirifer audaculus* (A); Gastropoda: bellerophontid gastropod (A), Pteropoda?: *Tentaculites attenuatus* (VA); Trilobita: *Trimerus (Dipleura) dekayi* (P); Echinodermata: crinoid columnals (A). 49 feet from top (869 feet)—Brachiopoda: *Tropidoleptus carinatus* (C), *Camarotoechia congregata* (C), *C. prolifica* (A), *Delthyris sculptilis* (C). *Mediospirifer audaculus* (A); Pelecypoda: *Actinopteria decussata* (P), *Leiopteria* sp. (C), *Cornellites flabella* (P); Pteropoda?: *Tentaculites attenuatus* (C).	59	918
2.	Sandstone, fine-grained, medium light gray, weathering light gray, commonly in 6-inch undulose beds. Thin-section no. 11-834. Thickness 21 feet. Sandstone, coarse- to very coarse-grained, yellowish gray, in 1- to 8-foot undulose beds. Conglomeratic beds 24 to 26 feet from top of unit. Thickness 14 feet. Sandstone, argillaceous, medium light gray, in one-half- to 7-inch undulose beds. Interbeds of coarse-grained sandstone and shale with pebbles and nodules as large as 4 inches in diameter. Numerous ripple marks. Thickness 6 feet. Sandstone, coarse- to very coarse-grained, yellowish gray, in regular, commonly 1- to 4-foot beds. Conglomerate, yellowish gray, in 3-inch to 5-foot beds 59 feet below top of unit. Numerous ripple marks. Thickness 31 feet. Fossiliferous 35 to 41 feet from top (818-824 feet)—Brachiopoda: *Spinocyrtia granulosa girtyi* (A); Pelecypoda: *Cornellites flabella* (C).	72	859
3.	Shale, sandy, micaceous, very slightly calcareous, medium gray (N5), weathering me-		

Unit		Unit Thickness	Cumulative Thickness
	dium light gray (N6), breaks into one-half- to 3-inch irregular fragments. One-inch concretions of siltstone present. Fossiliferous zones as noted: 3 to 10 feet from top (777-784 feet)—Bryozoa: indeterminate bryozoan sp. (P), *Fenestella* sp. (P), *F.* cf. *F. emaciata* (C); Brachiopoda: *Rhipidomella vanuxemi* (C), *Protoleptostrophia perplana* (P), *Douvillina inaequistriata* (P), *Pholidostrophia pennsylvanica* (A), *Devonochonetes coronatus* (P), *Longispina mucronatus* (C), *Productella spinulicosta* (A), *Camarotoechia congregata* (A), *Mediospirifer audaculus* (A), *Spinocyrtia granulose* (P), *S. granulosa girtyi* (P), *Athyris spiriferoides* (A), *Centronella*? sp. (P); Pelecypoda: *Cornellites flabella* (A), *Cypricardinia indenta* (P), *Palaeoneilo muta* (P), *P. tenuistriata* (P), *Modiomorpha concentrica* (P), Gastropoda: *Platyceras (Platyostoma) euomphaloides* (P); Trilobita: *Greenops boothi* (P); Echinodermata: crinoid columnals (A). 10 to 20 feet from top (767-777 feet)—Bryozoa: *Fenestella* cf. *F. emaciata;* Brachiopoda: *Rhipidomella vanuxemi* (P), *Protoleptostrophia perplana* (P), *Douvillina inaequistriata* var. *immatura.* (P), *Schuchertella variabilis* (A), *Longispina mucronatus* (C), *Productella spinulicosta* (C), *Mediospirifer audaculus* (A), *Spinocyrtia granulosa* (P), *Athyris spiriferoides* (A); Pelecypoda: *Actinopteria boydi* (C), *A. decussata* (P), *Pterinopecten (Pseudaviculopecten) princeps* (C), *Cornellites flabella* (C), *Modiomorpha concentrica* (P); Gastropoda: *Platyceras (Platyostoma) euomphaloides* (P); Trilobita: *Phacops rana* (P). 40 to 46 feet from top (741-747 feet)—associated with oolitic chamosite—Brachiopoda: *Ambocoelia umbonata*? (C), *Centronella*? sp. (C), Cephalopoda: *Spyroceras nuntium*? (C); *Polychaeta*?: *Taonurus* sp. (C).	46	787
4.	Hematite, oolitic, shaly.	2	741
5.	Sandstone, coarse- and medium-grained, medium light gray, weathering light olive gray, in regular 1- to 24-inch, averaging 5-inch beds. Thirty percent of unit formed by very		

Unit		Unit Thickness	Cumulative Thickness
	coarse-grained sandstone in upper 19 feet, and 1-foot bed of conglomerate 39 feet below top. Unit deeply weathered and has punky aspect 19 to 23 feet below top. Base of unit profuse with short, linear sole markings. Thin-section no. 11-717.	54	739
6.	Shale, sandy, medium olive gray, weathering light olive gray. Siltstone, calcareous, medium light greenish gray (5G46/1), in 1- to 4-inch beds, forms 30 percent of unit. Contains exploratory drift.	7	685
7.	Sandstone, medium-grained, bright light olive gray, in 5- to 7-foot ripple-marked cross-beds. Beds of conglomerate form 20 percent of unit. Minor interbeds of shale. Organic fragments include *Callixylon*?.	50	678
8.	Siltstone, argillaceous, olive gray, weathering light olive gray, in 6- to 12-inch, commonly 8-inch beds. Lower half of unit very argillaceous. Sandstone, calcareous, medium greenish gray, in 1- to 6-inch beds, forms 10 percent of unit. Somewhat punky, fossiliferous zone at base of unit (612 feet)—Anthozoa: *Favosites sp.* (A); Brachiopoda: *Rhipidomella penelope*? (P), *Devonochonetes coronatus* (P), *Mediospirifer dromgoldi*? (VA); *Spinocyrtia granulosa* (P); Pelecypoda: *Cornellites flabella* (P).	17	628
9.	Sandstone, fine-grained, light olive gray, in 2- to 3-foot undulose beds. Organic fragments present. Bedding thickness greatest in upper half of unit. Thickness 17 feet. Siltstone, medium dark gray, weathering olive gray, in 6- to 36-inch regular beds. Breaks into flags 1 to 2 inches thick. Exposed at base of northern quarry. Thickness 11 feet. Fossiliferous zones as noted: 16 feet below top (595 feet)—Anthozoa: *Pleurodictyum styloporum* (C); Bryozoa: *Fenestella* cf. *F. emaciata* (C), *Sulcoretepora* cf. *S. incisurata* (VA); indeterminate bryozoan sp. (P); Brachiopoda: *Protoleptostrophia perplana* (C), *Schuchertella variabilis* (C), *Tropidoleptus carinatus* (P), *Devonochonetes coronatus* (A), *D. scitulus* (A), *Camarotoechia congregata* (A), *C. prolifica* (C), *Delthyris*		

Unit		Unit Thickness	Cumulative Thickness
	sculptilis (P), *Mediospirifer audaculus*? (A); Pelecypoda: *Actinopteria decussata* (C), *Cornellites flabella* (C), *Paleoneilo muta* (C), *Leptodesma* sp. (P); Pteropoda?: *Tentaculites attenuatus* (P); Trilobita: *Trimerus (Dipleura) dekayi* (C).	28	611
10.	Concealed. Siltstone and fine-grained sandstone, in 1- to 4-inch beds partially exposed along road. Interbeds of shale form 50 percent of partial exposures.	57	583
11.	Sandstone, fine-grained, medium gray and medium greenish gray, in 1- to 65-inch, averaging 9-inch cross-beds. Interbeds of shale form less than 5 percent of unit. Thin-section nos. 11-497 and 11-475. Thickness 51 feet. Siltstone, very argillaceous, light olive gray, commonly in 3-inch beds. Thickness 8 feet.	59	526
12.	Concealed.	36	467
13.	Sandstone, fine-grained, medium gray, weathering dusky yellow, and siltstone, light olive gray, commonly in 1- to 4-foot beds. Sandstone, calcareous, in 1-foot long lenticular concretions 25 feet below top. Sandstone argillaceous, fine-grained, in 2-foot undulose bed, with black, undulose laminae 19 feet below top.	29	431
14.	Concealed interval north of middle quarry.	66	402
15.	Sandstone, fine-grained, medium olive gray, weathering dusky yellow, and siltstone, medium dark gray, commonly in 2- to 3-foot beds. Thickness 81 feet. Sandstone, fine-grained, argillaceous, medium gray, weathering medium light greenish gray, in 1- to 2-foot beds that may be cross-beds. One-foot bed of gray sandy shale, 84 feet below top of unit (252 feet), forms 25 percent of subunit. Thickness 4 feet. Sandstone, fine- to medium-grained, medium gray to light olive gray, weathering light olive gray, commonly in 2- to 3-foot beds that may be cross-beds. Few thin sequences of coarse-grained sandstone form minor percent of subunit. Organic fragments present. Thin-section nos. 11-239 and 11-217. Thickness 61 feet. Sandstone, fine-grained, medium gray, weathering, light to medium olive gray, in 6- to		

Unit		Unit Thickness	Cumulative Thickness
	24-inch beds that may be cross-beds. Siltstone, calcareous, in 2- to 3-inch beds, and shale form less than 5 percent of subunit. Thickness 25 feet. Sandstone, fine-grained, very argillaceous, calcareous, medium gray, weathering light olive gray, in 1- to 6-inch irregular beds. Thickness 12 feet. Siltstone, light olive gray, in 2- to 12-inch beds. Interbeds of shale form 5 percent of subunit. Exposed in south wall of middle quarry. Thickness 7 feet. Fossiliferous zones as noted: 69 feet below top (267 feet)—Brachiopoda: *Longispina mucronatus* (C), *Mediospirifer audaculus* (C); Pelecypoda: *Aviculopecten bellus* (P); Trilobita: *Greenops boothi*? (P). 86 feet below top (250 feet)—Brachiopoda: *Rhipidomella vanuxemi* (P), *Cyrtina hamiltonensis* (P), *"Spirifer"* sp. (C). 86 to 90 feet below top (250-246 feet)—Brachiopoda: *Rhipidomella vanuxemi*? (C).	190	336
Lower shale member			
16.	Concealed. Probably Gander Run member.	14	146
17.	Shale, sandy, medium dark gray, weathering medium gray. More sandy toward top. Crinoid columnals present. Upper 60 feet of unit is exposed along road, lower portion exposed in southern quarry. Faulting is evident. Thickness 85 feet. Sandstone, fine-grained, medium gray with limonitic specks, in one 3½-foot bed. Base truncated by fault that continues into underlying shale. Thickness 3.5 feet. Shale, sandy, micaceous, medium gray, weathering medium light gray. Lenses and 1- to 6-inch beds of calcareous sandstone, medium gray, form 5 percent of subunit. Thickness 24.5 feet. Fossiliferous 95 feet below top—Brachiopoda: *Lingula*? sp. (P); Pelecypoda: *Nuculites triqueter* (P).	113	132
18.	Sandstone, fine-grained, dark gray (N3), weathering medium gray, in lenticular beds ranging from 2 to 5 feet thick. Exposed 100 feet west of power station in southern quarry.	12	19
19.	Shale, silty, medium olive gray.	7	7

SUMMARY

Mahantango Formation	918′ exposed
upper shale member	concealed
Montebello Member	772′ exposed
lower shale member	146′ exposed

Section 2.—Section at Marysville

South of Marysville, a highway cut along U. S. Route 15, and a railroad cut provide excellent exposures of the Montebello Member of the Mahantango Formation. An abandoned quarry west of the highway also exposes some of the lower units that are exposed on the road. The exposure is a cross-section through Little Mountain, and is located 4600 feet south of the principal intersection in Marysville.

On the Harrisburg, Pennsylvania Quadrangle, the base of the section along the highway is at lat. 40°20′ N. and 1600 feet west of long. 76°55′ W.

At Marysville nearly all of the Montebello Member is exposed, but neither the lower shale member nor the upper shale member is exposed. None of the section as described is concealed, but those units exposed along the railroad are somewhat inaccessible to close examination owing to the overgrowth of poison ivy.

Although low angle faulting is common in this section, its effect generally, is not significant. However, unit 6 and part of unit 7 have been eliminated by faulting except at the top of the exposure on the west side of the highway. This adds approximately 30 feet to the section as traversed along the road.

Although units 1 through 14 are exposed along the railroad and only units 4 through 14 are exposed along the highway, the highway exposure is more accessible and the displacement by faulting is more easily accounted for.

The upper limit of the *Mediospirifer*-coralline Zone is at 425 feet, two feet below the top of unit 11. The *Subrensselandia claypolii* Zone is represented here by the fossiliferous horizon at 294 feet, in the lower 35 feet of unit 11. Lenticular occurrences of fossil at 64 feet in the lower part of unit 14 represent the *Paraspirifer acuminatus* Zone in this section.

Harrell Formation
Concealed
Hamilton Group
Mahantango Formation
Upper shale member
Concealed
Montebello Member

Unit	*Unit Thickness*	*Cumulative Thickness*
1. Siltstone and fine-grained sandstone, grayish-red (5R4/2) and brownish-gray, in places medium gray to medium light gray, in regular 2-inch to 2-foot beds. Interbedded shale forms minor amount of unit. Fossiliferous 25 to 33 feet from top (763-771 feet)—Brachiopoda: *Devonochonetes syrtalis* (C), *Tropidoleptus carinatus* (A), *Camarotoechia* sp. (P), *"Spirifer" tullius* (P); Echinodermata: large crinoid columnals (P).	53	796
2. Sandstone, medium-grained, light-olive-gray (5Y5/2) to medium-light-gray (N6), in 2-inch to 2-foot beds. Interbedded with argillaceous, coarse- and very coarse-grained sandstone having an irregular appearance. Fossiliferous 37 feet below top of unit (706 feet)—Brachiopoda: *Spinocyrtia granulosa* (C).	74	743
3. Shale, sandy, grayish-olive, becoming more sandy toward top of unit. Upper half more properly argillaceous sandstone. Contact with overlying sandstone faulted. Fossiliferous 3 feet below top of unit (666 feet)—indeterminate horn corals (A).	50	669
4. Shale, hematitic, and hematite, sandy, oolitic.	3	619
5. Sandstone, medium-grained, medium-light-gray, weathering light olive gray, in undulose to regular beds. Three-foot bed underlain by 5-foot bed. Thickness 8 feet. Sandstone, medium-grained, medium-light-gray, weathering light olive gray, 1-inch to 1-foot cross-beds. Thinner beds are more argillaceous and have irregular, lumpy appearance. Shale between 44 and 46 feet below top of unit. Thickness 50 feet.	58	616
6. Shale. Inaccessible, at top of exposure on west side of highway.	5	558
7. Sandstone, fine- to coarse-grained, medium-gray (N5) to medium-dark-gray, weathering pale olive (10Y6/2), cross-bedded in 6- to 24-inch beds in lower 25 feet and 3- to 6-inch beds in upper 28 feet. Conglomerate, in several beds less than 2 inches thick, 17 to 28 feet below top of unit. Thin-section no. 6-500.	53	553
8. Shale, sandy, medium-dark-olive-gray (5Y3/2).		

Unit		*Unit Thickness*	*Cumulative Thickness*
	One- to three-inch beds of light olive gray sandstone from less than 10 percent of unit.	11	500
9.	Sandstone, medium-grained, medium-gray, weathering light olive gray, in 4- to 12-inch regular to undulose beds. Thickness 15 feet. Sandstone, argillaceous, medium-gray, weathering light olive gray, in 2- to 3-inch regular to undulose beds. Thickness 6 feet. Sandstone, fine-grained, medium-gray, weathering light olive gray, in 1- to 2-foot and 4- to 5-foot cross-beds. Thickness 5 feet. Fossiliferous zones as noted: Top of unit (489 feet)—Anthozoa: indeterminate horn corals (C); Brachiopoda: *Protoleptostrophia perplana* (A), *Tropidoleptus carinatus* (C), *"Spirifer"* sp. (VA); Pelecypoda: *Glyptodesma erectum*? (P). 20 feet below top (469 feet)—Brachiopoda: *Camarotoechia congregata*? (VA), *Mediospirifer* sp. (C). At base of unit (463 feet)—Echinodermata: crinoid columnals (VA).	26	489
10.	Interbedded sandstone and shale. Sandstone, argillaceous, medium-grained, medium-gray, weathering light olive gray, in 6- to 12-inch cross-beds. One-fourth- to six-inch interlayers of shale form 30 percent of this part of unit. Thickness 3 feet. Shale, sandy, medium-olive-gray (10Y4/1), weathering grayish brown (5Y4/2). Siltstone, slightly calcareous, medium-gray and medium-dark-gray, in 1- to 16-inch cross-beds predominate toward top of subunit. One 2½- to 4-foot undulose siltstone marks top of subunit. Thickness 33 feet. Fossiliferous zone at top of unit (463 feet)—Brachiopoda: *Tropidoleptus carinatus* (P), *Mediospirifer dromgoldi* (VA).	36	463
11.	Sandstone, medium-grained, medium-gray, weathering light olive gray, in 6- to 16-inch cross-beds. Four-inch, 6-inch, and 1-foot conglomerates are 27, 26, and 24 feet below top respectively. Sandstone, very fine-grained, medium-dark-gray, weathering yellowish gray (5Y7/2), in 4-foot bed marks top of unit. Thickness 31 feet. Sandstone, coarse- and very coarse-grained, medium-gray, weathering light olive gray, in 6- to 16-inch cross-beds. Thickness 4 feet.		

Unit		Unit Thickness	Cumulative Thickness
	Sandstone, medium-grained, medium-gray to medium-dark-gray, in 3- to 10-foot cross-beds. Thickness 21 feet.		
	Sandstone, coarse-grained, medium-gray, weathering light olive gray, in 3- to 10-foot cross-beds. Upper 5 feet of subunit is argillaceous with lumpy appearance. Thin-section no. 6-363. Thickness 35 feet.		
	Sandstone, medium-grained, medium-gray, weathering light olive gray, commonly in 6-inch regular beds. One-foot conglomerate 14 feet below top of subunit. Thickness 21 feet.		
	Sandstone, medium-grained, light-olive-gray, in 3- to 8-foot cross-beds. Argillaceous sandstone in upper 9 feet of subunit. Thickness 19 feet.		
	Sandstone, medium-grained, medium-gray, weathering pale greenish gray (5GY7/1), in 2- to 18-inch regular to slightly undulose beds. Thin-section no. 6-293. Thickness 37 feet.		
	Fossiliferous zones as noted: 2 feet below top (425 feet)—Anthozoa: indeterminate coral spp. (C), cyathophylloid coral sp. (P), *Pleurodictyum styloporum* (C); Bryozoa: *Fenestella* cf. *F. emaciata* (P); Brachiopoda: *Devonochonetes coronatus* (C), *Retichonetes marylandicus* (VA), *Mediospirifer belliplicata* (A), *"Spirifer"* sp. (P); Trilobita: *Trimerus (Dipleura) dekayi* (P). 13 feet below top (414)—Bryozoa: *Fenestella* cf. *F. emaciata*? (P), *Fenestella* cf. *F.* sinuosa (P); Brachiopoda: *Protoleptostrophia perplana* (P), *Tropidoleptus carinatus* (P), *"Spirifer"* sp. (A); Echinodermata: crinoid radix (P). 17 feet below top (410 feet)—Bryozoa: indeterminate bryozoan sp. (P), *Polypora* sp. (P), *Sulcoretepora* cf. *S. incisurata* (C); Brachiopoda: *Protoleptostrophia perplana* (P), *Devonochonetes coronatus* (C), *Camarotoechia* sp. (C), *Cyrtina hamiltonensis* (P), *Mediospirifer belliplicata* (VA); Pelecypoda: *Actinopteria decussata* (P), *Pterinopecten (Pseudaviculopecten) princeps* (P), *Cornellites flabella* (C); Trilobita: *Trimerus (Dipleura) dekayi* (P); Echinodermata: crinoid radix? (P).		

Unit		Unit Thickness	Cumulative Thickness
	46 feet below top (381 feet)—Brachiopoda: *Mediospirifer bellitropis* (A). 133 feet below top (294 feet)—Brachiopoda: *"Spirifer"* sp. (A), *Subrensselandia claypolii?* (A).	168	427
12.	Interbedded shale and sandstone. Sandstone, argillaceous, pale-olive-gray (5Y6/2), in 2- to 18-inch beds. Sandstone, fine-grained, light-olive-gray, in 3- to 8-inch regular to undulose beds, forms 40 percent of subunit. Thickness 21 feet. Sandstone, medium-grained, pale-grayish-red (10R5/2), weathering yellowish gray, in 2- to 19-inch regular to slightly undulose beds. Thickness 2 feet.	23	259
13.	Shale, silty, slightly micaceous, light-olive-gray and very dark-gray. Very thin lenticular beds of sandstone in upper 5 feet.	25	236
14.	Sandstone, medium-grained, medium-gray, weathering light olive gray, in ½- to 4-foot commonly 1-foot cross-beds. Sandstone, very coarse-grained, hematitic, in 6-inch bed 27 feet below top. Unidentified fossils 28 feet below top (183 feet). Thickness 84 feet. Sandstone, fine-grained, medium-gray, weathering light olive gray, in 3- to 12-inch cross-beds. Abundant organic fragments. Thickness 30 feet. Sandstone, very fine-grained, argillaceous, medium-greenish-gray, in poorly defined beds. Thin-section no. 6-93. Thickness 5 feet. Conglomerate and very coarse-grained sandstone, light-olive-gray, weathering dusky yellow, in 19- to 24-inch cross-beds. Thickness 5 feet. Sandstone, fine- to medium-grained, medium-gray, weathering light olive gray, in 2- to 4-foot cross-beds. Sandstone, very argillaceous, forms 10 percent of unit. Thickness 70 feet. Sandstone, fine-grained, very argillaceous, dusky-yellow, in 2- to 18-inch, commonly 7-inch cross-beds. Thickness 17 feet. Fossiliferous zones as noted. 126 feet below top (85 feet)—Brachiopoda: *Rhipidomella penelope?* (P), *"Spirifer"* sp. (A), *Camarotoechia* sp. (P). 147 feet below top (64 feet)—Brachiopoda: *Paraspirifer acuminatus* (C).	211	211

Unit	*Unit Thickness*	*Cumulative Thickness*
Lower shale member		
Concealed		

SUMMARY

Mahantango Formation	796′ exposed
upper shale member	concealed
Montebello Member	796′ exposed
lower shale member	concealed

Section 3.—Section at Dromgold

Section 3 at Dromgold, and section 4 at Falling Springs actually are parts of one more or less continuous section exposed along State Route 850 west of Dromgold. On the basis of repetition of lithologic units and faunal assemblages, it has been concluded that the section has been faulted and that the Montebello Member is almost completely duplicated. The overly large total thickness of the entire section—2720 feet—from the base at Falling Springs to the top at Dromgold strongly suggests faulting; sections 3 and 4, therefore, are separated by this fault.

The base of the Dromgold section, as described, is located along the road on the crest of a hill just south of Camp Carson Long, at a point 5,800 feet north of lat. 40°20′ N. and 11,000 feet west of long. 77°10′ W. on the New Bloomfield, Pa. Quadrangle. Neither the upper nor the lower contact of the Mahantango Formation is exposed in this section. However, the Burket Member of the overlying Harrell Formation is exposed behind a garage immediately behind the Dromgold store at Dromgold. Nearly 70 percent of the section is concealed. A 139-foot concealed interval separates the section at Dromgold from the section at Falling Springs.

The upper and lower *Tropidoleptus carinatus* Zones are both represented in unit 1, in the upper shale member. In the Montebello Member the *Subrensselandia claypolii* Zone is represented by the fossiliferous horizon at 484 feet, in unit 11; the *Paraspirifer acuminatus* Zone is suggested by the occurrence of *Rhipidomella penelope* at 1649 feet, in unit 13.

The Dromgold and Falling Springs sections were measured by plane tabling.

Unit	*Unit Thickness*	*Cumulative Thickness*
Harrell Formation		
Burket Member		
Unit		
1. Shale, deeply weathered to medium light gray. Overlain by siltstone and shale of the		

Unit	*Unit Thickness*	*Cumulative Thickness*
Harrell. Exposed behind garage at Dromgold.	3	176
2. Concealed. Interval includes part of the Mahantango Formation as well as the Burket Member of the Harrell Formation.	173	173

Hamilton Group

Mahantango Formation

Upper shale member

Unit

1. Shale, silty, micaceous, light-greenish-gray (5GY8/1) to greenish-gray (5GY5/2), weathering light olive gray (5Y5/2), breaks into small plates, in regular 1- to 3-inch beds.
   Siltstone, argillaceous, medium-gray (N5), in regular 1- to 3-inch, commonly 2-inch beds 55 to 67 feet below top of unit, and one 8-inch bed of siltstone 51 feet below top, forms 30 percent of upper 20 feet of unit.
   Fossiliferous zones as noted: 38 feet below top (1224 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (A); Brachiopoda: *Rhipidomella vanuxemi* (C), *Protoleptostrophia perplana* (A), *Tropidoleptus carinatus* (A), *Devonochonetes coronatus* (P), *C. lepidus* (P), *"Spirifer" tullius* (A), *Tylothyris pauliformis* (P); Echinodermata: crinoid columnals (A). 40 feet below top (1222 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (C); Brachiopoda: *Rhipidomella leucosia* (C), *Protoleptostrophia perplana* (C), *Tropidoleptus carinatus* (P), *"Chonetes" lepidus* (C), *Camarotoechia* sp. (C), *"Spirifer" tullius* (C); Echinodermata: crinoid columnals (C). 42 feet below top 1220 feet)—Brachiopoda: *Protoleptostrophia perplana* (P), *Mucrospirifer mucronatus* (P). 54 feet below top (1208 feet)—Brachiopoda: *Tropidoleptus carinatus* (A), 55 feet below top (1207 feet)—Brachiopoda: *Rhipidomella leucosia* (A), *Tropidoleptus carinatus* (VA), *Mediospirifer audaculus?* (P); Pelecypoda: *Actinopteria* sp. (P), *Cornellites flabella* (P), *Modiomorpha concentrica* (P); Echinodermata: crinoid columnals (C). 58 feet below top (1204 feet)—Brachiopoda: *Tropidoleptus carinatus* (VA),

Unit		Unit Thickness	Cumulative Thickness
	"Spirifer" tullius? (P); Gastropoda: *Crenistriella crenistria* (C).	90	1262
2.	Concealed. Farm road leads off north from main road at top of this concealed interval.	55	1172
3.	Hematite, oolitic and shaly. Partially concealed.	2	1117
4.	Siltstone, medium-greenish-gray (5GY5/1), weathering light brownish gray (5YR6/1), in undulose 3- to 8-inch beds, commonly 1-foot beds in upper 12 feet of unit. Shale forms 10 percent of lower 25 feet of subunit. Partially concealed. Thickness 37 feet. Siltstone, medium-greenish-gray, weathering light brownish gray, in undulose ½- to 2-inch beds. Partially concealed. Thickness 6 feet.	43	1115
5.	Concealed. Presumably shale or claystone of the upper shale member.	55	1072
Montebello Member			
6.	Sandstone fine- to medium grained, greenish-gray (5GY6/1), in uneven 3- to 12-inch beds. One 4-foot bed beneath 6-inch bed of hematitic claystone marks top of unit. Few crinoid columnals.	7	1017
7.	Siltstone, micaceous, grayish-purple (5P4/2), in poorly defined 1- to 2-foot beds.	5	1010
8.	Concealed. Grayish-purple siltstone loose in bank and in one small slumped exposure 38 feet below top of concealed interval.	106	1005
9.	Sandstone, fine-grained, light-gray, weathering light greenish gray, cross-bedded in 2- to 3-foot beds. Top of unit marked by 1-foot conglomerate. Thickness 3 feet. Sandstone, coarse-grained, light-gray, weathering light greenish gray, cross-bedded in 2- to 3-foot beds. Thickness 36 feet. Concealed. Thickness 5 feet. Sandstone, fine-grained, light-gray, weathering light greenish gray, cross-bedded in 1- to 2-foot beds. Thickness 33 feet.	77	899
10.	Concealed.	282	822
11.	Sandstone, fine-grained, medium- to light-gray, weathering light greenish gray, cross-bedded in 1- to 4-foot beds. Cross-bedded conglomerate, up to 15 inches thick, 34 feet below top of unit, grades upward into coarse-grained sandstone. Lower portion partly concealed.		

Unit		Unit Thickness	Cumulative Thickness
	Fossiliferous zones as noted: 34 feet below top (506 feet)—Brachiopoda: *Mediospirifer dromgoldi* (A). 44 feet below top (496 feet)—Brachiopoda: *Mediospirifer dromgoldi* (A). 56 feet below top (484 feet)—Brachiopoda: *Mediospirifer dromgoldi* (C), *Subrensselandia claypolii* (VA).	87	540
12.	Concealed. Camp Carson Long situated in lower part of this concealed interval.	208	453
13.	Sandstone, argillaceous, fine-grained, greenish-gray, weathering light brownish gray, cross-bedded in 8- to 18-inch beds. Exposed in road cut and in gutter. Partially concealed. Thickness 54 feet. Sandstone, argillaceous, medium- to coarse-grained, grayish-olive (10Y4/2), weathering light olive gray, cross-bedded in 3- to 18-inch beds. Beds relatively thicker toward top of subunit. Thickness 28 feet. Fossiliferous 54 feet below top (191 feet)—Brachiopoda: *Rhipidomella penelope* (C), *Tropidoleptus carinatus* (P), *Devonochonetes coronatus* (A), *"Spirifer"* sp. (C).	82	245
14.	Concealed. This interval is located on the crest of the hill.	115	163
15.	Siltstone, medium-light-gray (N6), weathering light olive gray, in 10- to 12-inch beds. Partially concealed interval 13 to 33 feet below top is deeply weathered moderate reddish orange (10R6/6). This unit is exposed at the western end of the cut on the crest of the hill.	48	48
	Fault		

SUMMARY

Harrell Formation	3′ exposed
Burket Member	3′ exposed
Mahantango Formation	1262′ exposed
upper shale member	245′ exposed
Montebello Member	1017′ exposed
Fault	

Section 4.—Section at Falling Springs

This section continues west from section 3 and exposes the Montebello Member and the lower shale member along State Route 850 paralleling Sherman Creek in the gap through Pisgah and Rattlesnake ridges. The base of the section as described is in the Marcellus Formation in the westernmost of two small borrow pits on the north side of the road at a point 6,700 feet north of lat. 40°20′ n., and 13,800 feet west of long. 77°10′ W., in the New Bloomfield, Pa. Quadrangle. The top of the Falling Springs section is separated from the bottom of the Dromgold section, near the top of the rise in the road, by a concealed interval. Units 1 through 5 are seen along the rise in the road; units 7 through 11 are located between this hill and a small bridge to the northwest. About 50 percent of the section is concealed. Measurements were done by plane tabling.

In unit 7, the *Subrensselandia claypolii* Zone is represented by a fossiliferous horizon, at 913 feet, with abundant *Mediospirifer dromgoldi*. The *Paraspirifer acuminatus* Zone is represented in unit 11 by the occurrence of *Rhipidomella penelope* in association with other fossils. Correlation of the 9-foot conglomerate with the *Mediospirifer*-coralline Zone elsewhere has been established primarily on the basis of the overlying *Devonochonetes coronatus* Zone (unit 2) containing abundant specimens of *Devonochonetes coronatus*, *Devonochonetes syrtalis*, and *Camarotoechia congregata*.

Hamilton Group

Mahantango Formation

Fault

Montebello Member

Unit	*Unit Thickness*	*Cumulative Thickness*
1. Siltstone, micaceous, grayish-purple (5P4/2), weathering medium brownish gray (5YR5/1), cross-bedded in 4-inch to 3-foot, commonly 1-foot beds. Shale, silty, grayish olive (10Y4/2), forms 40 percent of unit.	31	1292
2. Shale, silty, micaceous, grayish-olive (10Y4/2), weathering light olive gray, breaks into small plates. Siltstone, micaceous, grayish olive, weathering pale reddish brown, cross-bedded and undulosely bedded, in 1- to 10-inch beds, forms 40 percent of unit. Fossiliferous 14 feet below top of unit (1247 feet)—Brachiopoda: *Devonochonetes coronatus* (VA), *D. syrtalis* (A), *Camarotoechia congregata* (A), *C. prolifica* (C), *Delthyris sculptilis* (C), *Mediospirifer audaculus* (C),		

Unit		Unit Thickness	Cumulative Thickness
	Mucrospirifer mucronatus? (C); Pteropoda?: *Tentaculites attenuatus* (VA); Trilobita: *Trimerus (Dipleura) dekayi* (C); Echinodermata: crinoid columnals (C).	18	1261
3.	Concealed	21	1243
4.	Siltstone, grayish-purple (5P4/2), weathering medium brownish gray, commonly in 1-foot beds. Thin-section no. 16-1246.	9	1222
5.	Sandstone, fine-grained, light-olive-gray, cross-bedded in 1- to 3-foot beds. Thickness 6 feet. Conglomerate, pinkish-gray (5YR8/1), cross-bedded in 1- to 3-foot beds. Thickness 9 feet. Sandstone, coarse-grained, light-olive-gray to yellowish-gray, cross-bedded in 1- to 3-foot beds. Thickness 9 feet. Sandstone, medium-grained, yellowish-gray (5Y8/1), in undulose to even 1- to 3-foot beds. Thickness 7 feet. Sandstone, fine-grained, yellowish-gray, in undulose to even 1- to 3-foot beds. Thickness 38 feet.	69	1213
6.	Concealed. A cabin is situated in this concealed interval at the bottom of the hill, on the northern side of the highway.	208	1144
7.	Sandstone, medium- to fine-grained, yellowish-gray to pinkish-gray (5YR8/1), cross-bedded in ½- to 2-foot beds. Conglomerate and coarse-grained sandstone, medium-light-gray, in sequence 5 feet thick, 23 feet below top. Fossiliferous 23 feet below top (913 feet)—Brachiopoda: *Devonochonetes syrtalis* (C), *Mediospirifer dromgoldi* (A), *M. belliplicata* (P).	26	936
8.	Concealed.	91	910
9.	Sandstone, fine-grained, light-gray (N7), and siltstone, in thin beds. Poor, perhaps slumped exposure.	53	819
10.	Shale, sandy, light-olive-gray to grayish-olive (10Y4/2). Siltstone, argillaceous, grayish-olive, in 1- to 5-inch beds, with organic fragments, increases in proportion toward top.	15	766
11.	Sandstone, medium- to coarse-grained, light-gray (N7), weathering light greenish gray, in 1- to 18-inch, commonly less than 4-inch beds. Thickness 12 feet.		

Unit	Unit Thickness	Cumulative Thickness
Siltstone, greenish-gray, in 1- to 3-inch beds, with organic fragments. Thickness 38 feet. Sandstone, medium- to coarse-grained, light-gray, weathering light greenish gray, in 10- to 30-inch beds. Thickness 65 feet. Fossiliferous 51 feet below top (700 feet)—Brachiopoda: *Rhipidomella penelope* (C), *Leptaena "rhomboidalis"* (P), *Schuchertella variabilis* (P), *Tropidoleptus carinatus* (C), *Devonochonetes coronatus* (A), *Mediospirifer dromgoldi* (VA).	115	751
Lower shale member		
12. Concealed. Presumably part of the lower shale member. Within this interval a cabin is located on the northern side of the road; a small bridge and a dirt road leading off toward the northeast are situated west of the cabin. Thin beds of siltstone are partially exposed 400 feet below top of concealed interval.	536	636
13. Shale, micaceous, grayish-olive, weathering greenish gray. Siltstone, light-olive-gray, in 6-inch beds partially exposed 14 to 34 feet below top. Unit mostly concealed. Upper 6 feet of exposure in easternmost of two small borrow pits is of this unit.	100	100
Marcellus Formation		
1. Shale, slightly silty, black (N1), and very dark-gray (N2), weathering medium light gray, breaks into 1- to 3-inch plates and elongate fragments. Siltstone, light-olive-gray, in 1-inch to 1-foot beds at top of formation. Exposed in westernmost of two borrow pits and in lower portion of easternmost borrow pit.	27	27

SUMMARY

Mahantango Formation	1292′ exposed
Fault	
Montebello Member	656′ exposed
lower shale member	636′
Marcellus Formation	27′ exposed

Section 5.—Section at New Bloomfield

The upper shale member of the Mahantango Formation is well exposed in a large borrow pit along a dirt road on the southern flank of Mahanoy Ridge, leading east from State Route 34, just south of New Bloomfield. As described, the base of the section is 400 feet east of the intersection of Route 34 and the dirt road, at a point 400 feet south of lat. 40°25′ N., and 3000 feet west of long. 77°10′ W., on the New Bloomfield, Pa. Quadrangle. The top of the described section is located along the dirt road, about 500 feet east of the borrow pit, at a small exposure of the Burket and Harrell shales in contact. A small portion of the Montebello Member (unit 4), and the lower part of the upper shale member (unit 3) are partially exposed along the road west of the borrow pit. Only about 10 percent of the described section of the Mahantango Formation here is concealed.

This section is one of the finest in central Pennsylvania for fossil collecting from the upper part of the Mahantango Formation. All of the faunal zones of the upper shale member are present in this section. The disposition of zones within the section is as follows:

Sulcoretepora cf. *S. incisurata* Zone (280 to 299 feet)—unit 1
  Pustulatia pustulosa Zonule (287 to 295 feet)
  Craniops hamiltoniae Zonule (282 feet)
Upper *Tropidoleptus carinatus* Zone (244 to 273 feet)—units 1 and 2
Lower *Tropidoleptus carinatus* Zone (173 to 194 feet)—unit 2
  Rhipidomella leucosia Zonule (194 feet)
  "Spirifer" tullius Zonule (173 feet)
Devonochonetes scitulus Zone (71 to 83 feet)—unit 3
Mucrospirifer mucronatus Zone (47 feet)—unit 3

In addition, the New Bloomfield section is especially noteworthy inasmuch as the Tully Member of the Harrell Formation also is well exposed. The lower unit (unit 3) of this member contains a fauna typical of the Laurens Member of the Tully Formation in New York, whereas the upper unit (unit 2) contains a Mahantango-like fauna, complete with *Pustulatia pustulosa.*

Harrell Formation Burket Member *Unit*	*Unit Thickness*	*Cumulative Thickness*
1. Shale, deeply weathered ash-gray. Mostly concealed. Fossiliferous near base of unit (17 to 25 feet)—Pteropoda?: *Styliolina fissurella* (A).	73	89

Unit	*Unit Thickness*	*Cumulative Thickness*
Tully Member		
2. Claystone, silty, light- to medium-olive-gray (5Y5/2). Fossiliferous 9 to 10 feet below top (6 to 7 feet)—Bryozoa: indeterminate bryozoan spp. (A), *Fenestella* cf. *F. emaciata* (A), *Fenestella* cf. *F. sinuosa* (C), *Sulcoretepora* cf. *S. incisurata* (A), fistuliporoid bryozoan sp. (C); Brachiopoda: *Rhipidomella vanuxemi* (C), *Retichonetes vicinus* (P), *Pustulatia pustulosa* (A), *Tylothyris pauliformis* (A), *Cyrtina hamiltonensis* (A); Pelecypoda: *Pterinopecten hermes* (C); Ostracoda: *Hibbardia lacrimosa* (A); Echinodermata: crinoid columnals (VA).	11.5	16
3. Siltstone, very clayey, deeply weathered dark yellowish brown. Unit has punky appearance. Fossiliferous throughout (0 to 4.5 feet)—Brachiopoda: *Leiorhynchus mesacostale* (VA), *Emmanuella subumbona* (VA).	4.5	4.5
Hamilton Group		
Mahantango Formation		
Upper shale member		
Unit		
1. Claystone, silty micaceous, light- to medium-olive-gray, breaks into small chips. One-inch to one-foot concretions of limestone 31 and 32 feet below top. Claystone lacks silt in upper 31 feet of unit. Fossiliferous zones as noted: 13 feet below top (299 feet)—Anthozoa: thamnoporoid coral sp. (P); Bryozoa: indeterminate bryozoan sp. (P), *Fenestella* cf. *F. emaciata* (P), *Fenestella* cf. *F. sinuosa* (P), *Sulcoretepora* cf. *S. incisurata* (A), *Taeniopora exigua* (C); Brachiopoda: *Orbiculoidea tullia* (P), *Rhipidomella vanuxemi* (P), *Devonochonetes coronatus* (C), *Camarotoechia* sp. (P), *Atrypa reticularis* (P), *Elytha fimbriata* (P); Pelecypoda: *Palaeoneilo constricta* (C); Gastropoda: indeterminate gastropod sp. (P); Trilobita: *Phacops rana* (P); Branchiopoda: *Schizodiscus capsa* (P); Echinodermata: crinoid columnals (A). 17 feet below top (295 feet)—Bryozoa: *Fenestella* cf. *F. emaciata* (C), *Sulcoretepora* cf. *S. incisurata* (A); Brachiopoda: *Schuchertella variabilis* (P), *Longispina mucronatus* (P), *Truncalosia truncata* (P), *Pustulatia pustulosa* (C), *Elytha fim-*		

Unit		Unit Thickness	Cumulative Thickness

briata (C), *Mucrospirifer mucronatus* (A), *Ambocoelia umbonata* (P): Pelecypoda: *Pterinopecten (Pseudaviculopecten) princeps* (P), *P. hermes* (P); Gastropoda: *Bembexia capillaria* (P); Pteropoda?: *Styliolina bellistriata* (C); Ostracoda: *Hibbardia lacrimosa* (C), *Ponderodictya punctulifera?* (P), *Ulrichia spinifera* (A), *Octonaria bifurcata* (P), *Hollinella* cf. *H. scita* (C), *Bufina bicornuta* (P); Branchiopoda: *Schizodiscus capsa* (P); Echinodermata: crinoid columnals (VA). 25 feet below top (287 feet)—Anthozoa: zaphrentoid coral sp. (C); Bryozoa: *Fenestella* cf. *F. sinuosa* (C), *Fenestella* cf. *F. emaciata* (C), *Polypora* sp. (P), *Sulcoretepora* cf. *S. incisurata* (VA); Brachiopoda: *Rhipidomella vanuxemi* (P), *Protoleptostrophia perplana* (C), *Douvillina inaequistriata* (C), *D. inaequistriata* var. *immatura* (P), *Schuchertella variabilis* (P), *Tropidoleptus carinatus* (C), *Truncalosia truncata* (C), *Atrypa reticularis* (P), *Pustulatia pustulosa* (A), *Delthyris sculptilis* (P), *Elytha fimbriata* (P), *Mediospirifer audaculus* (P), *"Spirifer" tullius* (P), *Mucrospirifer mucronatus* (C), *Athyris spiriferoides* (P); Pelecypoda: *Aviculopecten equilatera* (P), *Cypricardella bellastriata* (P), *Cypricardinia indenta* (P), *Nucula bellistriata* (P), *N. lirata* (P), *Palaeoneilo constricta* (C), *P. muta* (C), *Modiella pygmaea* (P); Gastropoda: *Bembexia capillaria* (P); Cephalopoda: *Spyroceras nuntium?* (P); Trilobita: *Greenops boothi* (P), *Phacops rana* (P), Ostracoda: *Adelphobolbina medialis* (P), *Ctenoloculina cicatricosa* (C), *Ulrichia spinifera* (P), *Hibbardia lacrimosa* (P), *Bufina bicornuta* (P), *Euglyphella numismoides* (P), *Quasillites* sp. (A). 29 feet below top (283 feet)—Bryozoa: *Fenestella* cf. *F. emaciata* (C); Brachiopoda: *Douvillina inaequistriata* var. *immatura* (P), *Schuchertella variabilis* (C), *Delthyris sculptilis?* (P); pelecypoda: *Actinopteria decussata* (P). 30 feet below top (282) feet)—Bryozoa: fistuliporoid bryozoan sp. (P), *Fenestella* cf. *F. emaciata* (A), *Polypora* sp. (P), *Sulcoretepora* cf. *S. in-*

Unit		Unit Thickness	Cumulative Thickness
	cisurata (A), *Taeniopora exigua* (P); Brachiopoda: *Craniops hamiltoniae* (P), *Rhipidomella vanuxemi* (C), *Protoleptostrophia perplana* (P), *Douvillina inaequistriata* (C), *Schuchertella variabilis* (P), *Camarotoechia congregata* (P), *Elytha fimbriata* (P), *Mediospirifer audaculus* (P); Pelecypoda: *Cypricardinia indenta* (P), *Modiomorpha concentrica* (C), *Goniophora hamiltonensis* (P); Gastropoda: *Bembexia sulcomarginata* (P); Trilobita: *Greenops boothi* (P), *G. boothi* var. *calliteles* (C), *Phacops rana* (C); Ostracoda: *Ulrichia spinifera* (P); Echinodermata: crinoid columnals (VA). 32 feet below top (280 feet)—Brachiopoda: *Devonochonetes scitulus* (A); Pelecypoda: *Orthonota undulata* (P), *O.? parvula* (P), *Nucula bellistriata* (P), *Nuculites triqueter* (P), *Palaeoneilo constricta* (P); Cephalopoda: *Spyroceras nuntium?* (P); Trilobita: *Greenops boothi* (P). 39 feet below top (273 feet)—Brachiopoda: *Tropidoleptus carinatus* (C), *Devonochonetes scitulus* (C), *Mucrospirifer mucronatus* (P); Pelecypoda: *Nuculites triqueter* (P); Gastropoda: *Bembexia capillaria* (P); Trilobita: *Trimerus (Dipleura) dekayi* (P).	43	312
2.	Siltstone, argillaceous, medium-greenish-gray (5GY5/1), weathering dark yellowish brown (10YR4/2) and greenish gray, in 1- to 18-inch beds. Four-foot beds of shale, slightly silty, medium-greenish-gray, forms 20 percent of unit. Siltstone is thinner bedded (1- to 2-inch beds) and more argillaceous in upper 25 feet of unit. Fossiliferous zones as noted: At top of unit (269 feet)—Bryozoa: indeterminate bryozoan sp. (P); Brachiopoda: *Rhipidomella vanuxemi* (P), *Strophеodonta demissa* (P), *Tropidoleptus carinatus* (A), *"Chonetes"* sp. (A); Pelecypoda: *Palaeoneilo constricta* (C), *P. muta* (P); Pteropoda?: *Tentaculites attenuatus* (P); Trilobita: *Trimerus (Dipleura) dekayi* (C); Echinodermata: crinoid columnals (C). 1 foot below top (268 feet)—Brachiopoda: *Lingula ligea* (P), *Tropidoleptus carinatus* (A), *"Chonetes"* sp. (C), *Devonochonetes scitulus* (A), *"Spirifer" tullius* (C), *Mucro-*		

Unit		Unit Thickness	Cumulative Thickness

spirifer mucronatus (A); Pelecypoda: *Leiopteria* sp. (P), *Orthonota undulata* (C), *Pthonia sectifrons* (P), *Palaeoneilo constricta* (P), *P. plana* (P); Cephalopoda: *Spyroceras nuntium?* (P); Trilobita: *Trimerus* (Dipleura) *dekayi* (P); Echinodermata: crinoid columnals (C). 2 feet below top (267 feet)—Brachiopoda: *Tropidoleptus carinatus* (P), *Devonochonetes scitulus* (A), *"Spirifer" tullius* (C), *Mucrospirifer mucronatus* (P); Pelecypoda: *Cypricardella tenuistriata* (P), *Orthonota undulata* (P), *Nuculites oblongatus* (C), *Palaeoneilo constricta* (P); Gastropoda: *Crenistriella crenistria* (P). 3 feet below top (266 feet)—Brachiopoda: *Tropidoleptus carinatus* (C), *"Chonetes"* sp. (C), *Devonochonetes scitulus* (P), *"Spirifer" tullius* (P), *Mucrospirifer mucronatus* (C); Pelecypoda: *Nucula bellistriata* (C), *Palaeoneilo constricta* (P), *P. muta* (C); Trilobita: *Greenops boothi* (P). 7 feet below top (262 feet)—Bryozoa: fistuliporoid bryozoan sp. (P); Brachiopoda: *Lingula delia* (P), *Rhipidomella vanuxemi* (C), *"Chonetes"* sp. (C), *Elytha fimbriata* (P), *"Spirifer" tullius* (C), *Mucrospirifer mucronatus* (C); Pelecypoda: *Orthonota undulata* (P); Trilobita: *Trimerus (Dipleura) dekayi* (P). 23 feet below top (246 feet)—Brachiopoda: *Devonochonetes scitulus* (P), *"Spirifer" tullius* (P). 25 feet below top (244 feet)—Bryozoa: fistuliporoid bryozoan sp. (C); Brachiopoda: *Tropidoleptus carinatus* (C), *Mucrospirifer mucronatus* (P); Gastropoda: indeterminate gastropod sp. (P). 74 feet below top (195 feet)—Brachiopoda: *"Chonetes"* sp. (P), *Delthyris sculptilis* (C); Pteropoda?: *Styliolina fissurella* (A); Ostracoda: indeterminate ostracode sp. (A). 75 feet below top (194 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (VA); Brachiopoda: *Rhipidomella leucosia* (A), *R. vanuxemi* (C), *Protoleptostrophia perplana* (C), *Schuchertella variabilis* (C), *Tropidoleptus carinatus* (A), *Productella spinulicosta* (P), *Camarotoechia* sp. (A), *Delthyris sculptilis* (P), *Mediospirifer*

Unit		Unit Thickness	Cumulative Thickness
	audaculus (C), *Mucrospirifer mucronatus* (C); Pelecypoda: *Modiomorpha concentrica* (P); Trilobita: *Trimerus (Dipleura) dekayi* (C); Echinodermata: crinoid columnals (VA). 96 feet below top (173 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (C); Brachiopoda: *Tropidoleptus carinatus* (C), *"Spirifer" tullius* (C).	105	269
3.	Claystone, slightly silty, medium-olive-gray, weathering medium olive gray. Gradational contact with underlying unit. Partially concealed. Fossiliferous zones as noted: 14 feet below top (150 feet)—Brachiopoda: *Tropidoleptus carinatus* (P). 81 to 86 feet below top (78 to 83 feet) — Brachiopoda: *Tropidoleptus carinatus* (P), *Devonochonetes coronatus* (P), *D. scitulus* (A), *Mucrospirifer mucronatus* (C); Pelecypoda: *Actinopteria decussata* (P), *Pterinopecten (Pseudaviculopecten) princeps* (P), *Nucula bellistriata* (P); Trilobita: *Trimerus (Dipleura) dekayi* (C). 93 feet below top (71 feet)— Brachiopoda: *Devonochonetes scitulus* (C). 117 feet below top (47 feet)—Anthozoa: *Pleurodictyum styloporum* (P); Brachiopoda: *Tropidoleptus carinatus* (P), *Devonochonetes scitulus* (A), *Retichonetes vicinus* (A), *Mucrospirifer mucronatus* (C); Pelecypoda: *Cypricardella bellastriata* (P), *Nuculites oblongatus* (C); Gastropoda: *Loxonema delphicola* (C); Trilobita: *Phacops rana* (P); Ostracoda: *Ponderodictya punctulifera* (P).	129	164
Montebello Member			
4.	Siltstone, argillaceous, light- to medium-olive-gray. Silty claystone forms nearly 50 percent of unit. Partially concealed. Fossiliferous at top of unit (34 to 35 feet)—Brachiopoda: *Tropidoleptus carinatus* (A), *Devonochonetes coronatus* (C), *D. syrtalis* (C). *Delthyris sculptilis* (P), *Spinocyrtia granulosa* (P); Pelecypoda: *Nuculites oblongatus* (P); Ostracoda: *Hollinella tricollina* (P).	35	35

SUMMARY

Harrell Formation	89′ exposed
Burket Member	73′ exposed
Tully Member	16′

Mahantango Formation	312′ exposed
upper shale member	277′
Montebello Member	35′ exposed

Section 6.—Section at Amity Hall

This section in the roadcut along U. S. Route 22 parallel to the Juniata River exposes the upper shale member and part of the Montebello Member of the Mahantango Formation. It is located on the southeastern flank of Half Falls Mountain, and the top of the Hamilton Group is at the foot of a small valley at a point 15,800 feet north of lat. 40°25′ N., and 7,500 feet west of long. 77°00′ W. on the New Bloomfield, Pa., Quadrangle. The Tully and Burket Members of the Harrell Formation also are well exposed. As described, the lowermost unit (unit 12) is exposed in a small anticline on a rather sharp bend in the highway. About three-fourths of the described section is exposed. Additional exposures of the Montebello Member west of the base of the described section have not been included because of complication by faulting.

Faunal zones in the Amity Hall section are distributed as follows:
Sulcoretepora cf. *S. incisurata* Zone (407 to 417 feet)—unit 1
Pustulatia pustulosa Zonule (407 to 417 feet)
Lower *Tropidoleptus carinatus* Zone (204 feet)—unit 6
Mucrospirifer mucronatus Zone (150 feet)—unit 7
Devonochonetes coronatus Zone (27 feet)—unit 12
Mediospirifer-coralline Zone (22 feet)—unit 13

Harrell Formation Burket Member *Unit*	*Unit Thickness*	*Cumulative Thickness*
1. Shale, fissile, black (N1).	65	85
Tully Member? 2. Shale, calcareous, medium-gray (N5), weathering brownish gray (5YR4/1), breaks into small plates. Nodules and one 3-inch bed of medium-gray limestone form 5 percent of unit. Fossiliferous 17 feet below top (3 feet)—Bryozoa: indeterminate fenestellid sp. (A), *Sulcoretepora* cf. *S. sinuosa* (P), *Sulcoretepora* cf. *S. incisurata* (C), indeterminate bryozoan spp. (A); Brachiopoda: *Craniops hamiltoniae* (P), *Leiorhynchus* sp. (P), *Protoleptostrophia perplana* (P), *Delthyris sculptilis* (C), *Elytha fimbriata* (P), *Tylo-*		

Unit		Unit Thickness	Cumulative Thickness
	thyris pauliformis (C), *Ambocoelia umbonata?* (P), *Cyrtina hamiltonensis* (C), indeterminate brachiopod sp. (A); Pelecypoda: *Palaeoneilo constrica* (C), *Actinopteria decussata?* (P), indeterminate pelecypod sp. (P); Trilobita: *Phacops* sp. (P); Ostracoda: *Hibbardia lacrimosa* (A), *Euglyphella numismoides* (P), indeterminate ostracode sp. (A); Echinodermata: crinoid columnals (VA); Plantae: indeterminate sp. (C).	20	20

Hamilton Group
Mahantango Formation
Upper shale member

Unit		Unit Thickness	Cumulative Thickness
1.	Shale, medium-dark-gray (N4) to dark-greenish-gray, weathering light olive gray to greenish gray, breaks into small irregularly shaped fragments. Fossiliferous zones as noted: At top of unit (424 feet)—Brachiopoda: *Douvillina inaequistriata* (P), *Mediospirifer audaculus* (P), *Spinocyrtia granulosa* (P); Pelecypoda: *Cyricardinia indenta* (P), *Palaeoneilo muta* (P); Gastropoda: indeterminate gastropod sp. (P); Echinodermata: crinoid columnals (A). 7 feet below top (417 feet)—Bryozoa: *Fenestella* cf. *F. emaciata* (A), *Fenestella* cf. *F. sinuosa* (C), *Polypora* sp. (P); Brachiopoda: *Douvillina inaequistriata* var. *immatura* (C), *Schuchertella variabilis* (C), *"Chonetes"* sp. (C), *Devonochonetes scitulus* (P), *Camarotoechia* sp. (P), *Camarotoechia sappho* (C), *Atrypa reticularis* (C), *Pustulosa pustulosa* (A), *Elytha fimbriata* (C), *Spinocyrtia granulosa* (P), *Mucrospirifer mucronatus* (C); Cephalopoda; *Spyroceras nuntium?* (P); Trilobita: *Phacops rana* (C); Ostracoda: indeterminate ostracode sp. (P); Echinodermata: crinoid columnals (C). 9 feet below top (415 feet)—Bryozoa: *Fenestella* cf. *F. emaciata* (C), *Fenestella* cf. *F. sinuosa* (P), *Ptilopora* sp. (C), *Sulcoretepora* cf. *S. incisurata* (VA); Brachiopoda: *Craniops hamiltoniae?* (P), *Douvillina inaequistriata* var. *immatura* (P), *Schuchertella variabilis* (C), *Camarotoechia* sp. (C), *Atrypa recticularis* (P), *Pustulatia pustulosa* (VA), *Spinocyrtia granulosa* (P),		

Unit		Unit Thickness	Cumulative Thickness
	Leiorhynchus sp. (P), *"Spirifer"* sp. (P); Pelecypoda: *Palaeoneilo fecunda* (P); Ostracoda: *Ctenoloculina cicatricosa* (P), indeterminate ostracode sp. (P); Echinodermata: crinoid columnals (VA). 10 feet below top (414 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (A), *Taeniopora exigua* (C); Brachiopoda: *Protoleptostrophia perplana* (P), *Rhipidomella vanuxemi* (P), *Douvillina inaequistriata* var. *immatura* (P), *Schuchertella variabilis* (C), *Camarotoechia* sp. (C), *Pustulatia pustulosa* (A), *Tylothyris pauliformis* (C), *Elytha fimbriata* (P); Pelecypoda: *Palaeoneilo constricta* (P); Gastropoda: *Bembexia capillaria* (P); Echinodermata: crinoid columnals (A). 11 feet below top (413 feet)—Brachiopoda: *Pustulatia pustulosa* (P); Pelecypoda: *Cypricardella bellastriata* (P), *Palaeoneilo constricta* (P); Trilobita: *Phacops rana* (P). 17 feet below top (407 feet)—Bryozoa: *Fenestella* cf. *F. emaciata* (C), *Fenestella* cf. *F. sinuosa* (C), *Polypora* sp. (P), *Sulcoretepora* cf. *S. incisurata* (A), *Taeniopora exigua* (P); Brachiopoda: *Craniops hamiltoniae* (P), *Douvillina inaequistriata* var. *immatura* (C), *Schuchertella variabilis* (C), *Atrypa reticularis* (A), *Atrypa spinosa* (P), *Pustulatia pustulosa* (C), *Delthyris sculptilis* (P), *Elytha fimbriata* (C), *Spinocyrtia granulosa* (C); Pelecypoda: *Actinopteria decussata* (P), *Cypricardinia indenta* (P), *Palaeoneilo muta?* (C); Gastropoda: *Loxonema delphicola* (P); Trilobita: Phacops *rana* (C), *Greenops boothi* (P); Ostracoda: indeterminate ostracode sp. (A); Echinodermata: crinoid columnals (VA.).	27	424
2.	Concealed. Cabin north of road just below base of this concealed interval.	74	397
3.	Shale, medium-dark-gray to dark-greenish gray, weathering light olive gray to greenish gray. Fossiliferous zones as noted: 2 feet below top (321 feet)—Brachiopoda: *Tropidoleptus carinatus* (P), *Pustulatia pustulosa* (A). 10 feet below top (313 feet)—Brachiopoda: *Devonochonetes coronatus* (P); Pelecypoda: *Orthonota undulata* (P). 63 feet below top		

Unit		Unit Thickness	Cumulative Thickness
	(260 feet)—Brachiopoda: *Tropidoleptus carinatus* (P), *"Chonetes"* sp. (C); Pelecypoda: *Nucula bellistriata* (P). 78 feet below top (245 feet)—Brachiopoda: *Devonochonetes scitulus?* (C).	84	323
4.	Hematite, oolitic, shaly.	1	239
5.	Sandstone, fine- to medium-grained, medium-gray (N5), weathering pale olive, and siltstone, very dark-gray (N2), weathering dark gray (N3), in even and uneven beds ½ to 2½ feet thick. Fossiliferous at top of unit (238 feet)—Brachiopoda: *Atrypa reticularis* (P); Annelida: burrows (A).	24	238
6.	Siltstone, argillaceous, dark-gray, weathering light olive gray, in laminated, undulose to lenticular beds commonly 2 inches thick near base of unit, and 1 to 3 feet thick toward top. Shale forms nearly 40 percent of unit. Fossiliferous 10 feet below top (204 feet)—Bryozoa: indeterminate bryozoan sp. (A). *Sulcoretepora* cf. *incisurata* (A); Brachiopoda: *Craniops hamiltoniae* (P), *Tropidoleptus carinatus* (A), *Camarotoechia congregata* (A), *Schuchertella variabilis* (VA), *Devonochonetes syrtalis* (C). *Delthyris sculptilis* (P); Pteropoda?: *Tentaculites attenuatus* (C); Trilobita: *Trimerus (Dipleura) dekayi* (C); Ostracoda: *Hibbardia lacrimosa?* (P), indeterminate ostracode sp. (C); Echinodermata: crinoid columnals (A).	17	214
7.	Shale, silty, olive-gray (5Y4/1) to dark-greenish-gray, weathering light olive gray; less silty at base of unit. One- to four-inch beds of siltstone, calcareous, medium-gray, weathering dark yellowish brown (10YR4/2) form 15 percent of upper half of unit. Fossiliferous 47 feet below top (150 feet)—Brachiopoda: *Protoleptostrophia perplana* (P), *Devonochonetes scitulus* (A), *Longispina mucronatus* (C), *Mucrospirifer mucronatus* (VA); Pelecypoda: *Cypricardella bellastriata* (C), *Pterochaenia fragilis* (P), *Nucula bellistriata* (C), *Palaeoneilo constricta* (C), *Paracyclas lirata* (A); Gastropoda: *Bembexia laevis* (C), *Loxonema delphicola* (P); Cephalopoda: *Striacoceras typum?* (C).	51	197

Unit	*Unit Thickness*	*Cumulative Thickness*
Montebello Member		
8. Hematite, oolitic, 10 to 12 inches thick.	1	146
9. Sandstone, medium-grained and fine-grained, medium-dark-gray to dark-gray, weathering grayish olive green (5GY3/2), light olive gray, and grayish red (5R4/2), in uneven beds 6 to 12 inches thick, commonly 12 inches thick toward top. Unit varies in thickness considerably within the exposure, owing to lenticular character.	17	145
10. Siltstone, medium-dark-gray, in uneven beds 6 to 12 inches thick. Partially concealed.	21	128
11. Concealed. Partially exposed medium-dark-gray siltstone near base of concealed interval. Small exposure of siltstone near stone culvert 16 feet below top of concealed interval (91 feet).	54	107
12. Interbedded shale and siltstone. Siltstone and very fine-grained sandstone, dark-greenish-gray, weathering light olive gray, dark yellowish brown, and grayish olive, in cross-beds and lenticular beds commonly 2 to 4 inches, but up to 2 feet thick. Shale, sandy micaceous, forms less than 10 percent of lower half of unit, 80 percent of upper half. Minor lumpy, argillaceous sandstones above siltstones. Fossiliferous 26 feet below top (27 feet)— Brachiopoda: *Tropidoleptus carinatus* (VA), *Devonochonetes coronatus* (VA), *D. syrtalis* (VA), *Camarotoechia congregata* (A), *Mediospirifer audaculus macronotus* (P); Trilobita: *Trimerus (Dipleura) dekayi* (A); Echinodermata: crinoid columnals (A).	31	53
13. Sandstone, fine-grained and medium-grained, medium-gray, weathering light olive gray, in uneven and laminated beds 30 to 50 inches thick. Upper 5 feet of unit somewhat argillaceous and with abundant worm burrows. Thickness 12 feet. Sandstone, fine- to very fine-grained, medium-dark-greenish-gray, in cross-beds 2 to 8 inches thick. Sandstone, coarse-grained, in cross-beds 6 to 12 inches thick. Thickness 10 feet. Fossiliferous at top of unit (22 feet)— Anthozoa: *Pleurodictyum styloporum* (P); Brachiopoda: *Delthyris sculptilis* (P), *Spinocyrtia granulosa girtyi* (A), *"Spirifer"*		

Unit	Unit Thickness	Cumulative Thickness
sp. (C), *Athyris spiriferoides* (C); Pelecypoda: *Cornellites flabella* (P); Echinodermata: crinoid columnals and radix? (C).	22	22

SUMMARY

Harrell Formation	85′
Burket Member	65′
Tully Member	20′
Mahantango Formation	424′ exposed
upper shale member	278′
Montebello Member	146′ exposed

Section 7.—Section at Girtys Notch

This section, near the nose of Half Falls Mountain, is exposed in a road cut on U. S. Route 15, and also in a stream and borrow pit on the western side of the Susquehanna River 6 miles north of the intersection of Route 15 with U. S. Route 22 at Amity Hall. The top of the described section is located 4,300 feet south of lat. 40°30′ N., and 10,000 feet west of long. 76°55′ W., in the northwestern rectangle of the Harrisburg, Pa. Quadrangle. The base of the section, as described, is at the most northerly exposure of the south-dipping Montebello Member of the Mahantango Formation, and continues to the base of the Harrell shale which is exposed in a road cut-borrow pit south of the exposure of Mahantango. A small ravine west of the highway provides a fine exposure of the fossiliferous portion (unit 1) of the upper shale member of the Mahantango Formation. Unit 3, although not particularly noteworthy, is exposed in a small borrow pit west of the highway exposure. Units 5 through 17 are exposed along the highway, on the western side; a smaller exposure on the eastern side of the road exposes parts of units 11, 12, and 13. Less than one-fourth of the described section is concealed.

The faunal zones of the Mahantango Formation are distributed as follows:

Sulcoretepora cf. *S. incisurata* Zone (584 to 604 feet)—unit 1
  Pustulatia pustulosa Zonule (596 to 604 feet)
  Craniops hamiltoniae Zonule (584 to 586 feet)
Devonochonetes scitulus Zone (340 feet)—unit 6
Mucrospirifer mucronatus Zone (329 to 336 feet)—unit 6
Devonochonetes coronatus Zone (217 feet)—unit 11
Mediospirifer-coralline Zone (212 feet)—unit 11

Harrell Formation
Burket Member

	Unit Thickness	*Cumulative Thickness*
Unit		
1. Shale, fissile, black (N1). Exposed on south side of dirt road.	4	55
2. Concealed.	51	51

Hamilton Group
Mahantango Formation
Upper shale member
Unit

1. Shale, silty, olive-gray (5Y4/1), weathering brownish gray (5YR6/1) and greenish gray (5GY6/1). One- to six-inch concretions of medium-gray (N5) limestone present.
Fossiliferous zones as noted: At top of unit (604 feet)—Bryozoa: *Fenestella* cf. *F. sinuosa* (P), *Sulcoretepora* cf. *S. incisurata* (P); Brachiopoda: *Douvillina inaequistriata* var. *immatura* (P), *Atrypa spinosa?* (P), *Pustulatia pustulosa* (VA); Echinodermata: crinoid columnals (A). 4 feet below top (600 feet)—Anthozoa: zaphrentoid coral sp. (P); Brachiopoda: *Rhipidomella vanuxemi* (P); Gastropoda: *Platyceras (Platyostoma)* sp. (P); Trilobita: *Phacops rana* (C). 7 feet below top—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (A); Brachiopoda: *Pustulatia pustulosa* (A), 8 feet below top (596 feet)—Anthozoa: cyathophylloid and zaphrentoid coral spp. (C); Bryozoa: *Fenestella* cf. *F. sinuosa* (C), *Sulcoretepora* cf. *S. incisurata* (C); Brachiopoda: *Longispina mucronatus* (P), *Atrypa spinosa* (C), *Pustulatia pustulosa* (C), *Delthyris sculptilis* (C), *Tylothris pauliformis* (P), *Elytha fimbriata* (P); Pelecypoda: *Pterinopecten hermes?* (P), *Nucula bellistriata* (P), *Palaeoneilo muta* (P); Cephalopoda: *Spyroceras nuntium?* (P); Trilobita: *Phacops rana* (C); Ostracoda: *Hollinella* cf. *H. sella* (P), *Adelphohollbina medialis* (P), *Hibbardia lacrimosa* (C), *Euglyphella numismoides* (P), indeterminate ostracode sp. (A); Echinodermata: crinoid columnals (VA). 10 feet below top (594 feet)—Bryozoa: *Fenestella* cf. *F. sinuosa* (C); Brachiopoda: *"Chonetes"* sp. (P), *Elytha fimbriata* (P). In concretions of limestone 14 feet below top (590 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (P); Brachiopoda: *Pholidostrophia pennsylvanica*

Unit	Unit Thickness	Cumulative Thickness
(P), *Douvillina inaequistriata* var. *immatura* (C), *Tropidoleptus carinatus* (P), *Devonochonetes scitulus* (C), *Tylothyris pauliformis* (P); Echinodermata: crinoid columnals (C). 18 feet below top (586 feet)—Bryozoa: fistuliporoid bryozoan sp. (C), *Fenestella* cf. *F. sinuosa* (A); Brachiopoda: *Craniops hamiltoniae* (P), *Douvillina inaequistriata* (P), *Pholidostrophia pennsylvanica* (P), *Tropidoleptus carinatus* (C), *"Chonetes"* sp. (C), *Atrypa reticularis* (P), *Delthyris sculptilis* (C), *Tylothyris pauliformis* (P), *Mediospirifer audaculus* (C), *Spinocyrtia granulosa* (C), *Mucrospirifer mucronatus* (P); Pelecypoda: *Actinopteria decussata* (P), *Parallelodon hamiltoniae* (P), *Palaeoneilo muta* (C): Gastropoda: *Cyclonema* sp. (P); Pteropoda?: *Tentaculites attenuatus* (P); Trilobita: *Greenops boothi* (P), *Phacops rana* (P); Ostracoda: *Hollinella* sp. (A), indeterminate ostracode sp. (VA); Echinodermata: crinoid columnals (A). 19 feet below top (585 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (VA); Brachiopoda: *Petrocrania hamiltoniae* (P), *Protoleptostrophia perplana* (P), *Douvillina inaequistriata* (C), *D. inaequistriata* var. *immatura* (C), *Schuchertella variabilis* (P), *Devonochonetes syrtalis* (P), *"Chonetes"* sp. (C), *Delthyris sculptilis* (C), *Tylothyris pauliformis* (C), *Mediospirifer audaculus* (C), *Mucrospirifer mucronatus* (P), *Ambocoelia umbonata* (C): Pelecypoda: *Actinopteria decussata* (P), *Cypricardinia indenta* (C), *Palaeoneilo constricta* (P), *P. muta* (P); Trilobita: *Greenops boothi* var. *calliteles* (P), *Proetus rowi?* (P), *Phacops rana* (P); Ostracoda: *Adelphobolbina medialis* (C), indeterminate ostracode sp. (A); Echinodermata: crinoid columnals (VA). 20 feet below top (584 feet)—*Fenestella* cf. *F. sinuosa* (P), *Sulcoretepora* cf. *S. incisurata* (A), *Taeniopora exigua* (C); Brachiopoda: *Craniops hamiltoniae* (A), *Rhipidomella vanuxemi* (C), *Protoleptostrophia perplana* (C), *Megastrophia concava* (P), *Schuchertella variabilis* (C), *Devonochonetes coronatus* (P), *Productella*		

Unit		Unit Thickness	Cumulative Thickness
	spinulicosta (P), *Camarotoechia congregata* (P), *Delthyris sculptilis* (P), *Elytha fimbriata* (P), *Mucrospirifer mucronatus* (P), *Ambocoelia umbonata* (C); Pelecypoda: *Cypricardella bellastriata* (C), *Cypricardinia indenta* (P), *Nuculana diversa* (P), *Palaeoneilo constricta* (C), *P. muta* (C), *P. Perplana* (P), *P. emarginata* (C), *Grammysia arcuata?* (P); Gastropoda: *Crenistriella crenistria* (P); Trilobita: *Trimerus (Dipleura) dekayi* (P), *Greenops boothi?* (P), *Phacops rana* (P); Ostracoda: *Hollinella* cf. *H. sella* (P); Echinodermata: crinoid columnals (VA).	23	604
2.	Concealed. Interval between borrow pit and stream cut.	69	581
3.	Claystone, silty, medium-olive-gray (5Y5/1), weathering light olive gray (5Y5/2), in ½- to 1-inch beds. Exposed in small borrow pit.	37	512
4.	Concealed. Interval between borrow pit and exposure along highway.	35	475
5.	Sandstone, medium-grained, weathered light olive gray. Top of unit marked by 4-foot bed. Thickness 6 feet. Siltstone, medium-greenish-gray (5GY5/1), weathering light olive gray, in 8- to 24-inch beds. Increasingly shaly toward base of unit. Thickness 59 feet.	65	440
6.	Shale, silty, medium-gray, weathering medium olive gray, breaks into 1- to 4-inch plates. One- to six-inch beds of siltstone, light-olive-gray, form 20 percent of unit. Gradational contact with overlying unit. Old prospect drift near base of unit. Fossiliferous zones as noted: 31 feet below top (344 feet)—Pelecypoda: *Paracyclas lirata* (P). 35 feet below top (340 feet)—Brachiopoda: *Devonochonetes scitulus* (C), *Longispina mucronatus* (P); Pelecypoda: *Cypricardella bellastriata* (C), *Orthonota? parvula* (P), *Nucula bellistriata* (C), *N. varicosa* (C), *Nuculites oblongatus* (P), *Paracyclas lirata* (C); Gastropoda: *Crenistriella crenistria* (P), *Bembexia laevis* (C); Pteropoda?: *Tentaculites attenuatus* (P); Cephalopoda: orthocerid sp. (P); Ostracoda: indeterminate ostracode sp. (C). 39 feet below top (336 feet)—		

Unit	Unit Thickness	Cumulative Thickness
Brachiopoda: *Devonochonetes scitulus* (C), *Mucrospirifer mucronatus* (A); Pelecypoda: *Cypricardella bellastriata* (P), *Orthonota? parvula* (P), *Pterochaenia fragilis* (P), *Nucula* sp. (P), *Nuculites oblongatus* (P), *Palaeoneilo constricta* (C), *Paracyclas lirata* (C); Gastropoda: *Bembexia laevis* (P); Cephalopoda: *Bactrites? aciculum* (P); Pteropoda?: *Styliolina fissurella* (P); Ostracoda: *Ponderodictya punctulifera* (P). 46 feet below top (329 feet)—Brachiopoda: *Tropidoleptus carinatus* (C), *Longispina mucronatus* (A), *Mucrospirifer mucronatus* (A), *Leiorhychus limitare?* (C); Pelecypoda: *Actinopteria* sp. (P), *Cypricardella bellastriata* (C), *Orthonota parvula* (P), *Tellinopsis subemarginata* (P), *Pterochaenia fragilis* (C), *Nucula bellistriata* (C), *Nuculites oblongatus* (C), *N. triqueter* (C), *Palaeoneilo constricta* (C), *P. emarginata* (P), *Modiella pygmaea* (P), *Paracyclas lirata* (A); Gastropoda: *Crenistriella crenistria* (P), *Bembexia laevis* (C); Cephalopoda: orthocerid sp. (P), *Bactrites? aciculum* (C); Trilobita: *Greenops boothi* (C).	48	375
Montebello Member		
7. Hematite, oolitic, sandy. In places, limonitic sand forms lower part.	1	327
8. Sandstone, fine-grained, medium-greenish-gray, in 1- to 2-foot beds.	4	326
9. Siltstone, sandy, grayish-red (5R4/2), in massive beds in which thickness and nature of bedding are difficult to determine.	26	322
10. Sandstone, fine-grained, medium-greenish-gray, weathering olive gray, in 1- to 12-inch cross-beds commonly 5 inches thick.	17	296
11. Interbedded siltstone and shale. Siltstone, argillaceous, micaceous, dark-greenish-gray (5GY4/1) to medium-gray, in regular 4- to 8-inch beds. Shale forms 50 to 60 percent of unit. Basal 3 feet of unit composed of shale and medium-grained sandstone, medium-light-gray (N6), weathering pale olive (10Y6/2). Fossiliferous zones as noted: 62 feet below top (217 feet)—Bryozoa: fistuliporoid bryozoan sp. (P); Brachiopoda: *Tropidoleptus carinatus* (C), *Devonochonetes coronatus* (VA);		

Unit		*Unit Thickness*	*Cumulative Thickness*
	Pelecypoda: *Leiopteria* sp. (P). 67 feet below top (212 feet)—Bryozoa: *Sulcoretepora* sp. (P), *Fenestella* cf. *F. sinuosa* (P); Brachiopoda: *Tropidoleptus carinatus* (P), *Spinocyrtia granulosa girtyi* (A).	69	279
12.	Conglomerate, quartzitic, very-light-gray (N8) to yellowish-gray (5Y8/1). Pebbles up to 2 inches in diameter concentrated in upper 2 feet of unit, 10 feet below top, and at base of unit.	13	210
13.	Sandstone, very argillaceous, medium-gray, weathering greenish gray, in regular 3- to 8-inch beds. Upper 20 feet of unit crossbedded. Minor shale. Three-inch conglomerate 15 feet below top. Six-foot bed of argillaceous sandstone marks base.	51	197
14.	Sandstone, fine-grained, medium-gray, weathering greenish gray, in 3 to 24-inch, commonly 12-inch beds which are regular to undulose in lower 10 feet of unit and crossbedded in upper 45 feet of unit.	55	146
15.	Sandstone, fine-grained, very argillaceous, medium-dark-gray, weathering light olive gray, in regular ½- to 2½-inch beds. Sandy claystone in upper 5 feet. Contact with overlying unit is gradational. Thickness 20 feet. Sandstone, very fine-grained, very argillaceous, medium-greenish-gray, weathering olive gray, in regular 2- to 4-inch beds in lower half of subunit. Sandstone is less argillaceous and in 4- to 6-inch beds in upper half of subunit. Oolitic hematite marks top of subunit (71 feet). Thickness 30 feet.	50	91
16.	Sandstone, fine-grained, olive-gray, medium-greenish-gray, and medium-gray, weathering light olive gray, in 4-inch undulose beds and crossbeds. Shale forms 10 percent of unit, most prominent in lower 10 feet. Fossiliferous at top of unit (41 feet)—Brachiopoda: *Tropidoleptus carinatus* (P), *Mediospirifer millerstownensis?* (P), *spinocyrtia granulosa* (C), *Mucrospirifer mucronatus* (A), *"Spirifer"* sp. (C); Gastropoda: *Bembexia sulcomarginata* (C), *Ianthinopsis?* sp. (C); Pteropoda?: *Tentaculites attenuatus* (A), crinoid columnals (C).	20	41
17.	Sandstone, fine-grained, greenish-gray,		

Unit	Unit Thickness	Cumulative Thickness
weathering dusky yellow green (5GY5/2), in regular 4- to 12-inch beds. Two-foot beds mark top of unit.	21	21

SUMMARY

Harrell Formation	4′ exposed
Burket Member	4′ exposed
Tully Member	concealed
Mahantango Formation	604′ exposed
upper shale member	277′ exposed
Montebello Member	327′ exposed

Section 8.—Section at Millerstown

An excellent section of the Montebello Member of the Mahantango Formation is exposed along the Pennsylvania Railroad, on the western side of the Juniata River and south of the Breyers Ice Cream plant at Millerstown, Pennsylvania. The top of the described section is at a point 15,300 feet north of lat. 40°30′ N., and 300 feet east of long. 77°10′ W., in the south-central rectangle of the Millerstown, Pa. Quadrangle. The base of the section, as described is at the southern end of the most northerly retaining wall. Units 8 and 9 are interrupted by a second retaining wall; therefore, description of these units is taken partly from exposures along a dirt road paralleling the railroad. The upper 10 feet of the upper shale member of the Mahantango Formation (unit 1), and at least 57 feet of the Burket Member of the Harrell Formation are exposed in the yard of a farm house and at the junction of the Sugar Run dirt road and the road paralleling the railroad. Approximately 50 percent of the described section is concealed.

In the Millerstown section, the *Paraspirifer acuminatus* Assemblage Zone is represented by the fossiliferous horizons 14 and 19 feet above the base of the described section, in unit 9. The *Mediospirifer*-coralline Zone is represented by the fossiliferous horizon, with *Favosites* sp. at 349 feet, in unit 7.

Unit	Unit Thickness	Cumulative Thickness
Harrell Formation		
Burket Member		
Unit		
1. Shale, fissile, black (N1). Exposed at intersection of dirt roads and in yard of farm house. Partially concealed interval may include Tully.	57	57

Hamilton Group
Mahantango Formation

Unit	*Unit Thickness*	*Cumulative Thickness*
Upper shale member		
1. Shale, slightly silty, dark-greenish gray (5GY3/1), weathering light olive gray (5Y5/1). Highly contorted zone. Exposed at junction of dirt roads.	10	1199
2. Concealed. Interval between exposure along railroad and that at intersection of dirt roads. Presumably largely upper shale member.	548	1189
Montebello Member		
3. Sandstone, fine-grained, medium-greenish-gray (5GY5/1), weathering light olive gray, in 1- to 12-inch beds. Lower 30 feet of unit thicker bedded than upper part of unit. Twenty-inch conglomerate 40 feet below top of unit (601 feet). Top of unit at stone retaining wall. Fossiliferous zones as noted: 13 feet below top (628 feet) — Brachiopoda: *"Spirifer" tullius* (VA). 30 feet below top (611 feet) — Brachiopoda: *"Spirifer" tullius* (VA). 79 feet below top (562 feet) — Brachiopoda: *Camarotoechia congregata* (P), *"Spirifer" tullius* (A). 82 feet below top (559 feet) — Bryozoa: *Taeniopora exigua* (P); Brachiopoda: *Schuchertella variabilis?* (P), *Devonochonetes coronatus?* (C), *"Spirifer" tullius* (VA); Echinodermata: crinoid columnals (C).	92	641
4. Shale, silty, medium-greenish-gray, weathering light olive gray.	7	549
5. Siltstone, and fine-grained sandstone, medium-dark-gray, weathering medium greenish gray, in cross-beds and undulose beds, ½- to 4-feet thick. Two stone retaining walls 30 and 71 feet below top. Unit partially covered near railroad signal bridge. Fossiliferous zones as noted: 7 feet below top (535 feet)—Brachiopoda: *Devonochonetes coronatus* (C), *Mucrospirifer mucronatus* (VA). 89 feet below top (453 feet) — Brachiopoda: *Tropidoleptus carinatus* (VA).	96	542
6. Interbedded shale and siltstone. Siltstone, argillaceous, medium-dark-gray, weathering medium greenish gray, in 1- to 5-inch regular beds 43 to 59 feet below top (403 to 387 feet).		

Unit		Unit Thickness	Cumulative Thickness
	Shale and silty claystone form 10 per cent of unit. Thickness 70 feet. Shale, silty, micaceous, medium-greenish-gray, weathering light olive gray. Thickness 27 feet. Fossiliferous zones as noted. 14 feet below top (432 feet)—Brachiopoda: *Devonochonetes coronatus* (VA), *Mucrospirifer mucronatus* (VA); Pteropoda?: *Tentaculites attenuatus* (A). 82 feet below top (364 feet)—Brachiopoda: *Tropidoleptus carinatus* (VA).	97	446
7.	Sandstone, fine-grained, medium-dark-gray and sandstone, medium- to coarse-grained, dark-gray, weathering medium gray, in 2- to 12-inch undulose beds. Sandstone, deeply weathered to punky aspect, in 4-foot bed 19 feet below top (330 feet). Thickness 46 feet. Sandstone, very fine-grained, medium-dark-gray, weathering dusky yellow (5Y6/4), in 2- to 18-inch cross-beds. Interbeds of silty shale form less than 5 percent of subunit. Thickness 38 feet. Fossiliferous zones as noted: At top of unit (349 feet)—Anthozoa: *Favosites* sp. (P); unidentified invertebrate spp. (VA). 31 feet below top (318 feet)—Brachiopoda: *Retichonetes marylandicus* (P), *"Spirifer"* sp. (A). 76 feet below top (273 feet)—Brachiopoda: *Devonochonetes coronatus* (A), *Mediospirifer bellitropis* (A). 80 feet below top (269 feet)—Brachiopoda: *Devonochonetes coronatus* (A), *Mediospirifer bellitropis* (A); Trilobita: *Phacops rana* (P); Echinodermata: crinoid radix? (P).	84	349
8.	Sandstone, argillaceous, fine-grained, medium-gray, weathering light olive gray, in 2- to 6-inch regular beds. Organic fragments abundant. Thickness 55 feet. Sandstone, medium- to fine-grained, medium-gray, weathering dusky yellow, in 6- to 18-inch regular beds. One- to three-inch beds of argillaceous sandstone 40 to 50 feet below top of subunit. Minor interbeds of shale. Thickness 85 feet. Fossiliferous zones as noted: 1 foot below top (264 feet)—Brachiopoda: *Mediospirifer bellitropis* (VA). 3 feet below top (262 feet)—		

Unit		*Unit Thickness*	*Cumulative Thickness*
	Brachiopoda: *Mediospirifer belliplicata?* (P).	140	265
9.	Sandstone, medium- to coarse-grained, medium- to dark-gray, in 1- to 3-foot cross-beds. Thickness 104 feet. Sandstone, medium-grained, medium-greenish-gray, in 2- to 6-inch beds. Thickness 21 feet. Fossiliferous zones as noted: 79 feet below top (46 feet)—Brachiopoda: *Mediospirifer millerstownensis* (VA). 83 feet below top (42 feet)—Brachiopoda: *Mediospirifer millerstownensis* (VA). 97 feet below top (28 feet)—Brachiopoda: *Devonochonetes coronatus* (C), *Mediospirifer millerstownensis* (C); Gastropoda: *Loxonema delphicola?* (P). 106 feet below top (19 feet)—Brachiopoda: *Devonochonetes coronatus* (A), *Mediospirifer audaculus* (P), *M. dromgoldi?* (P), *Spinocyrtia granulosa girtyi* (C), *Paraspirifer acuminatus* (A). 111 feet below top (14 feet)—Brachiopoda: *Tropidoleptus carinatus* (VA), *Devonochonetes coronatus* (C), *Spinocyrtia granulosa girtyi?* (P), *Paraspirifer acuminatus* (P); Pelecypoda: *Sphenodus* sp.? (P); Gastropoda: bellerophontid gastropod sp. (C), *Bembexia sulcomarginata* (P), *Ianthinopsis?* sp. (VA); Echinodermata: crinoid columnals (C).	125	125

SUMMARY

Harrell Formation	57′ exposed
Burket Member	57′ exposed
Tully Member	concealed
Mahantango Formation	1199′ exposed
upper shale member	558′?
Montebello Member	641′ exposed

Section 9.—Section at Mahantango Creek

The section at Mahantango Creek is the type section for the Mahantango Formation as defined by Willard (1935). Unfortunately neither the base nor the top of the formation is exposed here, and most of the upper shale member also is concealed. The section, as here described, begins along a dirt road, paralleling the West Branch of Mahantango Creek, about 0.3 mile west of the bridge where Pennsylvania Route 104 crosses the North Branch of Mahantango Creek. This bridge is located 6,800 feet south of latitude 40°40′ N. and 12,100 feet west of longitude 76°55′ W. in the west-central rectangle of the Millersburg, Pennsylvania Quadrangle.

The lower shale member is partially exposed along the northern side of the dirt road; the Montebello Member is exposed in roadcuts on Route 104 on the eastern side of North Branch Mahantango Creek, just north of the bridge mentioned above; and the upper shale member is exposed partly along Route 104, but chiefly along the eastern bank of the creek, just north of the intersection of Route 104 with the road leading east toward McKee Half Falls. Measurements were made by tape and Brunton compass.

Both zonules of the lower *Tropidoleptus carinatus* Zone as well as the *Pustulatia pustulosa* Zone are in Unit 1 of this section.

	Unit Thickness	*Cumulative Thickness*
Harrell Formation		
Unit		
1. Shale, silty and siltstone, thin-bedded, weathering light olive gray (5Y4/1). Uppermost black shale occurrence at top of exposed unit.	171	567
2. Concealed interval of Harrell and Mahantango shale.	396	396
Hamilton Group		
Mahantango Formation		
Upper shale member		
Unit		
1. Shale, very slightly silty, becoming slightly calcareous toward top, medium-gray (N5) to medium-dark-gray (N4), weathering light olive gray and greenish gray. Beds of siltstone less than 1 inch thick compose less than 5 percent of unit. One 13-inch siltstone, cross-bedded, weathering dusky yellow and light olive gray, 26 feet below top (1219 feet). Fossiliferous zones as noted: 3 feet below top (1242 feet)—Brachiopoda: *"Chonetes"*		

Unit		Unit Thickness	Cumulative Thickness
	sp. (P), *Pustulatia pustulosa* (C); Echinodermata: crinoid columnals (A). 13 feet below top (1232 feet)—Brachiopoda: *Tropidoleptus carinatus* (C), *Devonochonetes coronatus* (P); Ostracoda: *Hollinella* cf. *H. sella* (P), ostracode sp. (C); Echinodermata: crinoid columnals (P). 14 feet below top (1231 feet)—Brachiopoda: *Rhipidomella vanuxemi* (C), *Tropidoleptus carinatus* (VA), *"Chonetes"* sp. (P), *Devonochonetes scitulus* (P); pelecypoda: *Cypricardella bellastriata* (P), *C. tenuistriata* (C), *Modiomorpha concentrica* (P). 33 feet below top (1212 feet)—Brachiopoda: *Tropidoleptus carinatus* (VA); Pelecypoda: *Tellinopsis subemarginata* (P), *Goniophora hamiltonensis* (P); Gastropoda: *Bembexia capillaria* (P); Echinodermata: crinoid columnals (A). 35 feet below top (1210 feet)—Brachiopoda: *Tropidoleptus carinatus* (VA), *"Spirifer" tullius* (C); Trilobita: *Trimerus (Dipleura) dekayi* (C); Echinodermata: crinoid columnals (VA). 47 feet below top (1198 feet)—Bryozoa: indet. bryozoan sp. (P); Brachiopoda: *Protoleptostrophia perplana* (P), *Megastrophia concava* (P), *Schuchertella variabilis* (P), *Devonochonetes coronatus* (VA), *D. scitulus* (C), *Retichonetes marylandicus* (C), *Tylothyris pauliformis* (P), *"Spirifer" tullius* (P), *Mucrospirifer mucronatus* (C); Pelecypoda: *Cypricardella tenuistriata* (P), *Orthonota undulata* (P), *Nucula bellistriata* (A), *Nuculites oblongatus* (P), *Nuculana diversa* (P), *Palaeoneilo constricta* (P), *P. muta* (P), indet. pelecypod spp. (C); Gastropoda: *Bellerophon leda* (C), *Crenistriella crenistria* (A), *Bembexia sulcomarginata* (P), *B. capillaria* (P), *Loxonema delphicola* (P); Pteropoda?: *Coleolus gracilis?* (P); Trilobita: *Trimerus (Dipleura) dekayi* (A); Ostracoda: *Hibbardia lacrimosa* (P); Echinodermata: crinoid columnals (C). 55 to 75 feet below top (1190 to 1170 feet)—Brachiopoda: *Devonochonetes scitulus* (C); pelecypoda: *Nuculites triqueter* (P).	75	1245
2.	Concealed. Intersection of Route 104 with crossroad is in this interval.	161	1170

Unit	*Unit Thickness*	*Cumulative Thickness*
3. Shale, silty, weathering light olive gray (5Y4/1). Siltstone, medium-gray (N5) and medium-dark-greenish-gray (5GY4/1), weathering light olive gray (5F4/1), in ½- to 1½-foot beds forms 25 percent of unit. Beds of argillaceous siltstone less than 1 inch thick form about 15 percent of unit. One-inch beds of siltstone, evenly bedded, dominate upper 25 feet.	86	1009
4. Concealed. Interval probably upper shale member.	137	923
Montebello Member		
5. Siltstone and sandstone, very fine-grained, cross-bedded, olive-gray (5Y4/1), in 2- to 6-inch beds, subconchoidal fracture.	10	786
6. Sandstone, medium-grained, medium-dark-gray (N4), weathering light olive gray (5Y4/1) with limonitic specks. Sandstone, fine-grained, weathering light olive gray and dusky yellow in lumpy, uneven beds commonly 2 to 4 inches thick. Thin shales form less than 5 percent of unit. Sandstone, coarse- and very coarse-grained in lenses in upper 5 feet of unit. Thickness 41 feet. Sandstone, fine- to medium-grained, light-gray (N7) to medium-greenish-gray, weathering dusky yellow to medium yellowish brown and light olive gray, cross-bedded and unevenly bedded in 10- to 24-inch beds. Thickness 33 feet. Sandstone, argillaceous and becoming less argillaceous toward top, slightly lumpy, weathering dusky yellow in 2- to 5-inch uneven beds. Some organic fragments present. Thickness 9 feet. Fossiliferous 52 feet below top (724 feet)—Pelecypoda: *Goniophora hamiltonensis?* (P), unidentified pelecypod sp. (C); Gastropoda: *Bembexia sulcomarginata* (C), *Ianthinopsis?* sp. (VA), *Cyclonema* sp. (P); Trilobita: *Trimerus (Dipleura) dekayi* (P); Echinodermata: crinoid columnals (C).	83	776
7. Sandstone, very fine-grained, weathering dusky yellow, in 3- to 10-inch beds, broadly cross-bedded. Thickness 8 feet. Sandstone, very fine- to medium-grained, medium-light-gray, weathering dusky yellow		

Unit		Unit Thickness	Cumulative Thickness
	and light olive gray; cross-bedded in beds 10-24 inches thick in upper two-thirds of subunit, less than 12 inches thick in lower third of subunit. Deeply weathered pockets suggest weathered fossil lenses, but no fossils were found. Thickness 40 feet. Sandstone, fine-grained, argillaceous, weathering dusky yellow and light olive gray, in lumpy uneven beds 2 to 6 inches thick. Some organic fragments. Thickness 5 feet. Sandstone, fine-grained, weathering dusky yellow with limonitic specks, cross-bedded in beds 2½ feet thick. Thickness 2½ feet. Sandstone, very-fine- to fine-grained, argillaceous, weathering dusky yellow, in beds 1 to 4 inches thick. Thin shales form less than 5 percent of unit. Organic fragments common. Thickness 14½ feet.	70	693
8.	Shale, sandy, weathering light olive gray (5Y4/1). Upper 12 feet of unit is sandstone, very fine- to fine-grained, weathering dusky yellow and light olive gray, cross-bedded in beds 12 to 18 inches thick. Some organic fragments and crinoid columnals. Top of unit defined by 1-foot sandstone underlain by 1½ foot argillaceous sandstone. Partially concealed.	68	623
9.	Sandstone, very fine- to fine-grained and siltstone, medium- to medium-light-gray, weathering light olive gray and moderate yellowish brown, in 6- to 10-inch uneven beds. Thin shale forms less than 5 percent of unit. Sandstone, very fine-grained, weathering dusky yellow, in ⅛- to 1-inch beds and argillaceous sandstone, in lower 10 feet. Organic fragments common in middle third. Sandstone, fine- to medium-grained, light-gray (N7) 17 feet below top (538 feet). Fossiliferous 26 feet below top (529 feet)—Brachiopoda: *Devonochonetes coronatus* (VA); Pteropoda?: *Tentaculites attenuatus* (P); Echinodermata: crinoid columnals (P). Partially concealed.	60	555
10.	Concealed. Sandstone partially exposed.	140	495
11.	Sandstone, argillaceous, light-olive-gray (5Y4/1) in irregular beds less than 1 inch thick. Sandstone, fine-grained, light-olive-gray, cross-bedded in 2- to 12-inch beds,		

Unit	Unit Thickness	Cumulative Thickness
forms 20 percent of unit. Fossiliferous near top (354 feet)—Bryozoa: *Sulcoretepora* sp. (C); Trilobita: *Trimerus (Dipleura) dekayi* (P); Echinodermata: crinoid columnals (C). Partially exposed along south flank of hill above dirt road west of Route 104.	15	355
Lower shale member		
12. Concealed interval. Probably part of lower shale member.	70	340
13. Shale, very slightly silty, olive-gray, weathering light olive gray, breaks into small elongate plates. Siltstone and very fine-grained sandstone, weathering light olive gray, cross-bedded in 1- to 6-inch beds, with some organic fragments in lower 50 feet. Thickness 260 feet. Shale, dark-olive-gray to black, laminated. One 1- to 2-foot thick siltstone, medium-light-gray, weathering moderate yellowish brown, cross-bedded in 1- to 2-inch beds. Thickness 10 feet.	270	270

SUMMARY

Harrell Formation	567′ exposed
Mahantango Formation	1245′ exposed
upper shale member	459′ exposed
Montebello Member	446′
lower shale member	340′ exposed

SECTIONS IN BEDFORD AND FULTON COUNTIES

Section 10.—Section at Websters Mills

This section is exposed in a roadcut along the northwestern side of Route 522, 0.1 to 0.5 mile south of Websters Mills, and is part of a faulted sequence between Dickeys Mountain to the south and Little Scrub Ridge to the north. The strata here are dipping very steeply to the west-northwest and are almost continuously exposed from the lower part of the Gander Run Member of the Mahantango Formation into the lower shales of the Harrell Formation.

On the Needmore, Pennsylvania Quadrangle the base of the described section is 8,400 feet north of latitude 39°50′ N., and 11,100 feet east of longitude 78°05′ W.

At Websters Mills, nearly all of the Gander Run, Chaneysville, and Frame Members is exposed. However, in this section the members are not well defined; generally the formation here is composed of silty shale

or claystone, and siltstone, with the siltstone being somewhat more prominent in the middle of the formation. The upper contact of the Mahantango Formation with the Harrell Formation is placed just above the *Sulcoretepora* Zone (1,230 feet) of the Frame Member. Neither the Burket black shale nor the Tully Member of the Harrell Formation is present in this section. The lower contact with the Marcellus Formation was not observed. However, north of the base of the described section, adjacent to a limestone wall, a few feet of badly contorted Marcellus black shale is exposed. This has not been included in the description of the section.

Units 1 through 5, and the upper 170 feet of unit 6 are exposed along the highway; the lower part of unit 6, the concealed interval of unit 7, and about 50 feet of unit 8 are in a brush-covered roadcut along an abandoned road above and back 30 to 100 feet from the highway. The lower part of the section, units 8, 9, and 10 are poorly exposed in the bank along the highway.

The *Sulcoretepora* Zone is represented in this section by the fossiliferous horizon at 1,230 feet, and although the fauna here is relatively diminished, typical species such as *Pustulatia pustulosa, Actinopteria decussata,* and *Hibbardia lacrimosa* are present. At 1,199 feet, in unit 2, very abundant specimens of *"Spirifer" tullius* are interpreted as representing the *"Spirifer" tullius* zonule of the *Tropidoleptus carinatus* Zone of other sections.

	Unit Thickness	*Cumulative Thickness*
Harrell Formation		
Unit		
1. Shale, slightly silty, weathered olive gray (5Y4/1) and dark yellowish brown (10YR4/2). Siltstone, weathered olive gray, in 1- to 6-inch beds forms 25 percent of unit. Stop sign and concrete storm drain are about position of base of this unit.	200	200
Hamilton Group		
Mahantango Formation		
Frame Member		
Unit		
1. Shale, slightly silty, weathered olive gray (5Y4/1) and dark yellowish brown (10YR4/2). Siltstone, weathered olive gray, in 1- to 6-inch beds forms 25 percent of unit. Position of upper contact uncertain. Fossiliferous zone and manganese? oolites 16 to 17 feet above base (1,230 feet)—Bryozoa: *Fenestella* cf. *F. emaciata* (C), *F.* cf. *F. sinuosa* (C), *Sulcoretepora* cf. *S. incisurata*		

Unit		Unit Thickness	Cumulative Thickness
	(VA), fistuliporoid sp. (A): Brachiopoda: *Stropheodonta demissa?* (P), *Douvillina inaequistriata* (C), *Atrypa reticularis* (C), *Pustulatia pustulosa* (C), *Delthyris sculptilis* (A), *Elytha fimbriata* (A), *Cyrtina hamiltonensis* (P); Pelecypoda: *Nucula bellistriata* (C), *Actinopteria decussata* (P); Pteropoda?: *Styliolina* sp. (C); Ostracoda: *Hibbardia lacrimosa* (C), Echinodermata: crinoid columnals (A).		
2.	Sandstone, fine-grained, medium-greenish-gray (5GY5/1) weathering olive gray, in 2-inch to 2-foot, commonly 1-foot beds, partly laminated, well cemented. Interbeds of shale form 5 percent of unit and increase in proportion toward top. Fossiliferous 15 feet below top (1199 feet) — Brachiopoda: *"Spirifer" tullius* (VA); Echinodermata: crinoid columnals (C).	20	1234
3.	Siltstone, argillaceous and micaceous, and sandstone, fine-grained, medium-greenish-gray (5GY5/1) and medium-gray, weathering olive gray, in 1- to 7-inch beds. Shale, weathered olive gray forms 20 percent of unit and comprises basal 9 feet of unit. Abundant *Taonurus* sp. Fossiliferous 33 feet below top (1156 feet) — Brachiopoda: *Tropidoleptus carinatus* (C), *Devonochonetes scitulus* (P), *"Spirifer" tullius* (C); Pelecypoda: *Nucula bellistriata* (P).	25	1214
4.	Sandstone, fine-grained, medium-greenish-gray, weathering olive gray to brownish gray, in 3- to 18-inch beds in upper half and 2- to 8-inch beds in lower half of unit. Conglomerate, dark-greenish-gray, weathering light olive gray, in 1½-inch bed 45 feet above base. Conglomerate and very coarse-grained sandstone, in 1- to 10-inch beds with shaly interbeds forming 5 percent of 15-inch sequence 50 above base. Fault separates units 3 and 4, so thicknesses are minimum. Storm drain is 6 feet above base.	51	1189
5.	Shale, silty, medium-light-gray (N6) to olive gray, weathering olive gray (5Y4/1), in 1- to 3-mm beds. Siltstone, light-olive-gray, weathering olive gray, in ½-inch lenses forms 5 percent of unit.	46	1138

Unit		Unit Thickness	Cumulative Thickness
	Fossiliferous zones as noted: 7 to 11 feet below top (1085 to 1081 feet)—Brachiopoda: *Tropidoleptus carinatus* (A), *Camarotoechia sappho* (P), *Mucrospirifer mucronatus* (C), *Delthyris sculptilis* (P); Pelecypoda: *Grammysia?* sp. (P), *Leiopteria* sp. (P). 48 feet below top (1044 feet)—Anthozoa: 2 indeterminate spp. horn corals (C); Bryozoa: indeterminate sp. (P); Brachiopoda: *Rhipidomella vanuxemi* (P), *Tropidoleptus carinatus* (C), *Stropheodonta demissa?* (P), *Protoleptostrophia perplana* (C), *Retichonetes vicinus* (P), *Mucrospirifer mucronatus* (A), *Mediospirifer belliplicata* (C); Pelecypoda: *Grammysia?* sp. (P), *Modiomorpha concentrica* (P), *Actinopteria decussata* (C), *Cypricardella bellastriata* (P); Trilobita: *Phacops rana* (P), *Echinomata*: crinoid columnals (A). 45 to 33 feet below top (1041 to 1029 feet)—Bryozoa: indeterminate sp. (P); Brachiopoda: *Tropidoleptus carinatus* (A), *Douvillina inaequistriata* (P), *Devonochonetes scitulus* (A), *Atrypa reticularis* (P), *Spinocyrtia granulosa* (C), *Mucrospirifer mucronatus* (C), *Mediospirifer* sp. (C), *Ambocoelia umbonata* (A); Pelecypoda: *Cornellites flabella* (C), *Pterinopecten princeps* (P), *Modiomorpha concentrica?* (P); Gastropoda: bellerophontid sp. (P); Echinodermata: crinoid columnals (A). 68 feet below top (1024 feet)—Brachiopoda: *Tropidoleptus carinatus* (A), *Devonochonetes scitulus* (C), *Mucrospirifer mucronatus* (P).		
Chancysville Member		82	1092
6.	Siltstone, argillaceous, medium-dark-gray (N4), weathering dark yellowish brown (10YR4/2), in 12- to 20-inch beds. Top of unit marked by sandstone, fine-grained, calcareous, medium-light-greenish-gray (5Y6/1), weathering light gray to medium brown, in 2-foot bed. Road marker 9/50 opposite top of unit. Thickness 9 feet. Claystone, shale, very silty, medium-gray (N5), weathering olive gray (5Y4/1), generally in indistinct beds but some 1- to 2-inch beds. Siltstone and sandstone, fine-grained, medium-dark-gray (N4), in 1- to		

Unit		Unit Thickness	Cumulative Thickness
	4-inch beds form 5 to 10 percent of unit and increase in number and thickness in upper half of unit, forming 20 percent of upper 100 feet of unit. Partially concealed. Thickness 335 feet.		
	Fossiliferous zones as noted: Top of unit (1010 feet)—Bryozoa: indeterminate sp. (P); Brachiopoda: *Rhipidomella leucosia* (P), *Tropidoleptus carinatus* (C), *Devonochonetes scitulus* (A), *Protoleptostrophia perplana* (P); Trilobita: *Phacops rana* (P). 6 feet below top (1004 feet)—Bryozoa: *Sulcoretepora* sp. (A); Brachiopoda: *Tropidoleptus carinatus* (C), *Devonochonetes coronatus* (A), *D. scitulus* (P), *D. syrtalis* (C), *Pholidostrophia pennsylvanica* (P), *Delthyris sculptilis* (C), *Mucrospirifer mucronatus* (VA); Gastropoda: *Bembexia sulcomarginata* (C); Echinodermata: crinoid columnals (A). 74 feet below top (936 feet)— Brachiopoda: *Mucrospirifer mucronatus* (C); Pelecypoda: *Nucula bellistriata?* (P); Gastropoda: *Bembexia capillaria* (P). 114 feet below top (896 feet)—Bryozoa *Sulcoretepora* cf. *S. incisurata* (C); Brachiopoda: *Devonochonetes scitulus* (A), *Retichonetes vicinus* (P), *Longispina mucronatus* (C), *"Spirifer" tullius* (P), *Mucrospirifer mucronatus* (A), *Athyris spiriferoides* (A), *Ambocoelia umbonata* (C); Pelecypoda: *Actinopteria decussata* (C), *Nucula bellistriata* (P), *Nuculites oblongatus* (P), *Modiomorpha concentrica* (C), *Goniophora hamiltoniae?* (P). 134 feet below top (876 feet)—Bryozoa: fistuliporoid bryozoan (P); Brachiopoda: *Schuchertella variabilis* (P), *Tropidoleptus carinatus* (VA), *"Chonetes"* sp. (P), *Devonochonetes scitulus* (C), *Mucrospirifer mucronatus* (C); Gastropoda: bellerophontoid gastropod sp. (C), *Ptomatis patulus* (P); Echinodermata: crinoid columnals (A). 158 feet below top (852 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (C); Brachiopoda: *Protoleptostrophia perplana* (A), *Mucrospirifer mucronatus* (A); Pelecypoda: *Paracyclas lirata* (P); Gastropoda: *Naticonema lineata* (P). 161 feet below top (849 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (C); Brachiopoda: *Tropidolep-*		

Unit		Unit Thickness	Cumulative Thickness
	tus carinatus (A); Echinodermata: crinoid columnals (A). 164 feet below top (846 feet)—Brachiopoda: *Mucrospirifer mucronatus* (A); Gastropoda: *Bembexia laevis* (P); Echinodermata: crinoid columnals (P). 166 feet below top (844 feet)—Brachiopoda: *Devonochonetes coronatus* (C), *D. scitulus* (C), *Mucrospirifer mucronatus* (VA); Gastropoda: *Bembexia sulcomarginata* (A). 169 feet below top (841 feet)—Brachiopoda: *Longispina mucronatus* (P), *Mucrospirifer mucronatus* (VA). 172 feet below top (838 feet)—Brachiopoda: *Mucrospirifer mucronatus?* (C). 185 feet below top (825 feet)—Brachiopoda: *Devonochonetes scitulus* (C), *Mucrospirifer mucronatus* (A). 200 feet below top (810 feet)—Brachiopoda: *Mucrospirifer mucronatus* (A); Gastropoda: *Bembexia sulcomarginata?* (C); Pteropoda?: *Tentaculites attenuatus* (A). 204 feet below top (806 feet)—Brachiopoda: *Devonochonetes syrtalis* (P), *D. scitulus* (A), *"Spirifer"* sp. (C); Pteropoda?: *Tentaculites attenuatus* (P). 239 feet below top (771 feet)—Brachiopoda: *Mucrospirifer mucronatus* (C); Gastropoda: *Bembexia sulcomarginata* (P); Cephalopoda: *Striacoceras typum?* (P); Pteropoda?: *Tentaculites attenuatus* (P). 254 feet below top (756 feet)—Brachiopoda: *Tropidoleptus carinatus* (C), *Devonochonetes syrtalis* (A), *Mucrospirifer mucronatus* (A), Gastropoda: *Bembexia sulcomarginata* (P); Trilobita: *Trimerus (Dipleura) dekayi* (P); Echinodermata: crinoid columnals (C). 281 feet below top (729 feet)—Brachiopoda: *Tropidoleptus carinatus* (VA), *Devonochonetes coronatus* (A), *"Spirifer"* sp. (P); Gastropoda: indet. gastropod sp. (A); Pteropoda?: *Tentaculites attenuatus* (C); Echinodermata: crinoid columnals (VA). 309 feet below top (701 feet)—Brachiopoda: *Devonochonetes scitulus* (VA), *Retichonetes marylandicus* (A), *Longispina mucronatus* (C), *Mediospirifer audaculus* (C); Pelecypoda: *Cornellites flabella* (P), *Glyptodesma erectum* (P). 311 feet below top (699 feet)—Brachiopoda: *Devonochonetes scitulus* (C), *Longispina*		

Unit		Unit Thickness	Cumulative Thickness
	mucronatus (VA), *"Spirifer" tullius* (C). 320 feet below top (690 feet)—Brachiopoda: *Tropidoleptus carinatus* (A), *Longispina mucronatus* (C), *"Spirifer"* sp. (P); Gastropoda: *Bembexia sulcomarginata* (P); Trilobita: *Trimerus (Dipleura) dekayi* (P); Echinodermata: crinoid columnals (P). 331 feet below top (679 feet)—Brachiopoda: *Tropidoleptus carinatus* (A), *"Chonetes"* sp. (C), *Delthyris sculptilis* (P); Pelecypoda: *Cornellites flabella* (P); Echinodermata: crinoid columnals (C).	344	1010
Gander Run Member			
7.	Concealed. Argillaceous siltstone partially exposed near intersection with road leading into bush.	121	666
8.	Shale, silty, weathered light olive gray (5Y5/2), in 1-mm to 1-inch beds. Siltstone, argillaceous, in poorly defined beds forms 20 percent of unit, more prominent in upper 250 feet of unit. Partially concealed. At top of unit (545 feet)—Brachiopoda: *Devonochonetes scitulus* (A); Pelecypoda: *Leiopteria laevis* (P), *Orthonota undulata* (C), *Paracyclas lirata* (P), *Leptodesma rogersi* (P), *Grammysioidea alveata* (P). Gastropoda: bellerophontoid gastropod sp. (P), *Crenistriella crenistria?* (P) *Bembexia sulcomarginata?* (C).	376	545
9.	Shale, deeply weathered to medium light gray.	142	169
10.	Shale, silty, weathered olive gray. Siltstone, argillaceous, medium-gray, weathering olive gray, forms 20 percent of unit.	27	27

SUMMARY

Harrell Formation	200′ exposed
Mahantango Formation	1,230′ exposed
Frame Member	220′
Chaneysville Member	335′
Gander Run Member	666′ exposed

Section 11.—Section at Chaneysville

In this section on the western limb of the Clearville syncline—southwestern extension of the Broadtop synclinorium—the Gander Run Member is exposed along Sweet Root Creek, and the Chaneysville Member and lower part of the Frame Member are exposed along the northside of the main road through town. This section has been supplemented by exposures along the dirt road over the hill just north of and above the main road.

The base of the section as described is along the creek at a point about 2,600 feet south of latitude 39°50′ N., and 1,600 feet east of longitude 78°30′ W. on the Clearville, Pennsylvania Quadrangle.

Although neither the base nor the top of the Mahantango Formation is exposed in this section, it is an especially important one inasmuch as it is the type section for the Gander Run, Chaneysville, and Frame Members as defined by Willard (1935c), and also because of the nearly continuous exposure. Less than 19 percent of the section is concealed.

The Harrell Formation? and units 1 through 6 of the Mahantango Formation are exposed in the roadcut along the main road. Unit 7 is exposed along the main road as well as along the dirt road over the hill. The lower, very fossiliferous part of unit 7 is exposed along the dirt road paralleling the strike of the formation. Below the concealed interval, the lowermost unit 9 is exposed along the creek and also on the southside of the main road.

The *Spirifer granulosa clintoui* fauna of the *Mucrospirifer* Zone is represented by the fossiliferous sequence between 583 and 592 feet; the *Lougispina* fauna of that same zone is between 519 and 536 feet. The *Mediospirifer* Zone with corals, numerous species of brachiopods, and the pelecypod species *Cornellites flabella* is represented by an extremely large assemblage between 282 and 301 feet, in the lower part of the Chaneysville Member.

NOTE: Since this section was described in 1956, highway construction has considerably altered the exposure.

	Unit Thickness	*Cumulative Thickness*
Harrell Formation?		
Unit		
1. Shale, fissile, medium-olive-gray. Partially concealed.	29	114
2. Concealed. May be Harrell or Mahantango. Section may be faulted in this interval.	85	85
Hamilton Group		
Mahantango Formation		
Frame Member		
Unit		
1. Shale, silty, micaceous, light-olive-gray		

Unit		Unit Thickness	Cumulative Thickness
	(5Y5/2). Nodules of siltstone less than 1 inch across.	37	733
2.	Siltstone, grayish-olive (10Y4/2), weathering light olive gray, in 1- to 12-inch beds. Slightly calcareous siltstone near base. Silty claystone in upper and lower parts of unit forms 40 to 50 percent. Fossiliferous 34 feet below top (662 feet)—Brachiopoda: *Mucrospirifer mucronatus* (C); Pelecypoda: *Palaeoneilo constricta* (P); Gastropoda: *Cyclonema* sp. (P).	47	696
3.	Shale, silty, medium-gray (N5), weathering light olive gray, breaks into 1- to 2-inch plates and pencil-shaped fragments.	19	649
4.	Concealed. Probably part of upper shale member.	38	630
Chaneysville Member			
5.	Siltstone, argillaceous, medium-gray, weathering grayish olive, in indistinct beds. Fossiliferous 0 to 9 feet below top (583 to 592 feet)—Anthozoa: auloporoid sp. (P); Bryozoa: *Fenestella* sp. (P); Brachiopoda: *Rhipidomella vanuxemi* (P); *Protoleptostrophia perplana* (P), *Tropidoleptus carinatus* (P), *Longispina mucronatus* (C), *Delthyris sculptilis* (C), *Spinocyrtia granulosa clintoni* (A), *Mucrospirifer mucronatus* (C), *"Spirifer"* sp. (P), *Athyris spiriferoides* (P); Pelecypoda: *Cornellites flabella* (C), *Glyptodesma erectum* (P), *Modiomorpha concentrica* (P); Trilobita: *Trimerus (Dipleura) dekayi* (P); Echinodermata: crinoid columnals and radix (C).	9	592
6.	Concealed. Partly exposed along upper road. Chiefly claystone with some beds of siltstone. *Mucrospirifer mucronatus* (VA) near top of concealed interval.	33	583
7.	Siltstone, argillaceous, grayish-olive, in beds 1 to 18 inches thick, dominates upper and lower parts of unit, supporting local ridges. Silty claystone and shale, olive gray, especially notable in middle of unit. Exposed along main and upper roads. Base of exposure (250 feet) along northerly trending road. Lowermost exposure along main road is at 495 feet. Fossiliferous zones as noted: 14 to 24 feet below top (526 to 536 feet)—Brachiopoda:		

Unit		Unit Thickness	Cumulative Thickness
	Devonochonetes coronatus (C), *D. syrtalis* (P), *D. scitulus* (C), *Retichonetes marylandicus* (P), *Longispina mucronatus* (A), *Mucrospirifer mucronatus* (VA); Pelecypoda: *Leiopteria* (sp.) (C); Gastropoda: *Crenistriella crenistria* (P), *Bembexia sulcomarginata?* (C); Pteropoda?: *Tentaculites* sp. (C); Echinodermata: crinoid columnals (C). 31 feet below top (519 feet)—Brachiopoda: *Retichonetes marylandicus* (P), *Longispina mucronatus* (P), *Mucrospirifer mucronatus* (A). 35 feet below top (515 feet)—Brachiopoda: *Tropidoleptus carinatus* (P), "*Chonetes*" sp. (P), *Mucrospirifer mucronatus* (VA). 52 feet below top (498 feet)—Brachiopoda: *Tropidoleptus carinatus* (VA), *Mucrospirifer mucronatus* (P). 149 to 167 feet below top (282 to 301 feet)—Anthozoa: indet. horn corals (C), auloporoid sp. no. 1 (A) *Pleurodictyum styloporum* (P); Bryozoa: fistuliporoid bryozoan (P), *Fenestella* cf. *F. emaciata* (C), *Sulcoretepora* cf. *S. incisurata* (C); Brachiopoda: *Rhipidomella vanuxemi* (A), *Protoleptostrophia perplana* (A), *Tropidoleptus carinatus* (A), *Devonochonetes coronatus* (P), *D. scitulus* (C), *Retichonetes marylandicus* (C), *Longispina mucronatus* (C), *Camarotoechia congregata* (A), *Cyrtina hamiltonensis* (A), *Elytha fimbriata* (P), *Mediospirifer audaculus* (A), *Spinocyrtia granulosa girtyi* (P), Fimbrispirifer *venustus* (P), *Mucrospirifer mucronatus* (A), *Athyris spiriferoides* (C); Pelecypoda: *Actinopteria decussata* (C), *Cornellites flabella* (C), *Palaeoneilo tenuistriata* (C); Gastropoda: *Bembexia sulcomarginata* (P); Trilobita: *Trimerus (Dipleura) dekayi* (C); Echinodermata: crinoid columnals (VA). 287 feet below top (263 feet)—Brachiopoda: *Spinocyrtia granulosa* (P).	300	550
Gander Run Member			
8.	Concealed. Probably part of Gander Run Member.	57	250
9.	Siltstone, argillaceous and slightly calcareous, medium-gray, weathering grayish olive, in 6- to 36-inch beds, averaging 18 inches thick. Few crinoid columnals exposed along eastern bank of creek.	193	193

SUMMARY

Harrell Formation?	114′ exposed
Mahantango Formation	733′ exposed
Frame Member	141′ exposed
Chaneysville Member	342′
Gander Run Member	250′ exposed

Section 12.—Section at Elk Lick Creek

This section is exposed in a borrow pit and in the bank on the eastern side of a dirt road parallel to Elk Lick Creek, and about 2 miles north of Chaneysville on the western limb of what the Second Survey termed the "Clearville Syncline." Although the exposure generally is poor and almost 90 percent is concealed, it is included to provide information about the fauna of the upper Frame Member and also about the nature of the contact of the Mahantango and overlying Harrell. This contact is gradational; the Frame Member of the Mahantango Formation becomes increasingly silty toward the Harrell Formation which includes well defined beds of argillaceous siltstone and sandstone.

Units 1 and 2 of the Mahantango Formation are exposed in a small borrow pit at a point 5,300 feet north of latitude 39°50′ N., and 3,950 feet east of longitude 78°30′ W. on the Clearville, Pennsylvania Quadrangle.

The *Sulcoretepora* Zone is well represented in this section by the fossiliferous sequence between 304 and 340 feet in units 1 and 2 of the Mahantango.

Harrell Formation *Unit*	*Unit Thickness*	*Cumulative Thickness*
1. Claystone and siltstone, olive-gray (5Y5/2). Partially exposed north along eastern side of road. Abundant specimens of *Mucrospirifer mucronatus.*	115	127
2. Sandstone, very fine-grained and siltstone, weathering grayish olive (10Y4/1), in 2- to 6-inch beds, commonly 3-inch beds. Thin shales form less than 10 percent of unit. Abundant specimens of *Mucrospirifer mucronatus.*	12	12
Hamilton Group		
Mahantango Formation		
Frame Member		
Unit		
1. Claystone, silty, medium-gray (N5), weathering pale olive (10Y6/2) to light olive gray		

Unit		Unit Thickness	Cumulative Thickness
	(5Y5/2), breaks into pencil-shaped and elongate fragments commonly 2 inches long. One- to three-inch nodules of limestone common near top. Fossiliferous 9 to 31 feet below top (318 to 340 feet)—Anthozoa: zaphrentoid coral (P), indet. horn coral (P), *Pleurodictyum styloporum* (C); Bryozoa: fustuliporoid bryozoan (P), *Fenestella* cf. *F. emaciata* (C), *Sulcoretepora* cf. *S. incisurata* (C), indet. bryozoan sp. (C); Brachiopoda: *Orbiculoidea doria?* (P), *Petrocrania hamiltoniae?* (P), *Craniops hamiltoniae* (A), *Rhipidomella vanuxemi* (C), *Protoleptostrophia perplana* (A), *Schuchertella variabilis* (A), *Tropidoleptus carinatus* (A), *Devonochonetes coronatus* (P), *D. scitulus* (C), *Atrypa reticularis* (C), *Delthyris sculptilis* (P), *Elytha fimbriata* (C), *Mediospirifer audaculus* (A), *Mediospirifer audaculus macronotus* (P), *Spinocyrtia granulosa* (A), *Mucrospirifer mucronatus* (VA), *Athyris spiriferoides* (A), *Ambocoelia umbonata* (A); Pelecypoda: *Actinopteria decussata* (P), *Pterinopecten (Pseudaviculopecten) princeps* (P), *Cypricardella bellastriata* (C), *Nucula bellistriata* (C), *Nucula* cf. *N. varicosa* (P), *Nucula* cf. *N. randalli* (C), *Palaeoneilo fecunda* (P), *P. emarginata* (C), *Modimorpha concentrica* (C); Gastropoda: *Bucanopsis leda* (P), *Bembexia sulcomarginata?* (P), *Loxonema delphicola* (C); Trilobita: *Trimerus (Dipleura) dekayi* (P), *Greenops boothi* (P), *Phacops rana* (P); Ostracoda: *Ctenoloculina cicatricosa* (P), *Adelphobolbina medialis* (A), *Hibbardia lacrimosa* (P), *Ponderodictya punctulifera* (VA).	32	349
2.	Siltstone, calcareous, medium gray (N5), weathering light olive gray. Fossiliferous throughout (304 to 317 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (A); Brachiopoda: *Rhipidomella vanuxemi* (P), *Tropidoleptus carinatus* (P), *Protoleptostrophia perplana* (C), *Mucrospirifer mucronatus* (A), *Mediospirifer audaculus* (P), *Ambocoelia umbonata;* Trilobita: *Trimerus (Dipleura) dekayi* (P), *Greenops boothi* (P); Echinodermata: crinoid columnals (A).	13	317

Unit	Unit Thickness	Cumulative Thickness
3. Silty claystone, siltstone, and fine-grained sandstone very poorly exposed along road, south of borrow pit. *Spinocyrtia granulosa clintoni* (A) near base of unit.	304	304

SUMMARY

Harrell Formation	127′ exposed
Mahantango Formation	349′ exposed

Section 13.—Section Along Turnpike at Everett

This section, on the western limb of the Broadtop synclinorium, is exposed on both sides of the Pennsylvania Turnpike south of the Raystown Branch of the Juniata River at Everett. Here, the members recognized in Chaneysville and Websters Mill are not well defined; rather the sequence is composed of interbedded siltstone and claystone. Although the beds of siltstone dominate two parts of the exposed section suggesting the Donation and Backbone Ridge Members in Huntingdon County, these units are not defined well enough at Everett to warrant subdivision. The base of the section as described is 1600 feet north of latitude 40°00′ N., and 11,550 feet east of longitude 78°25′ W. on the Everett, Pennsylvania Quadrangle.

An exposure of about 70 feet of the Needmore shale is separated from the Mahantango Formation by a concealed interval of about 700 stratigraphic feet.

Units 1 through 3 of the Mahantango Formation are exposed in one uninterrupted sequence. Although part of the Gander Run Member is partly exposed in a borrow pit off the Turnpike, it is not described in this section.

The thickness of the Mahantango, as exposed, is 742 feet.

Faunal zones recognized in this section are as follows:

Mucrospirifer mucronatus Zone—Unit 1—(347 to 560 feet)
Mediospirifer audaculus Zone—Units 1 and 2—(231 to 320 feet)

Hamilton Group
Mahantango Formation
Frame-Chaneysville Members (undifferentiated)

Unit	Unit Thickness	Cumulative Thickness
1. Interbedded siltstone and claystone. Siltstone, medium-gray (N5), in 2- to 18-inch commonly 6-inch beds. Silty claystone, medium-gray, weathering medium		

Unit		Unit Thickness	Cumulative Thickness

light gray (N6) and olive gray (5Y4/1) secondary in importance. Thickness 75 feet.

Claystone, silty, medium-gray, weathering medium light gray and olive gray. Nodules and 6-inch beds of medium gray siltstone, form minor percent of subunit. Storm drain at about base of subunit. Thickness 187 feet.

Siltstone, medium-gray, in 2- to 18-inch commonly 6-inch beds. Silty claystone, medium-gray, weathering medium light gray and olive gray, secondary in importance. Gradational contacts with units above and below. Thickness 127 feet.

Claystone, silty, medium-gray, weathering medium light gray (N6) and olive gray, breaks into 2-inch chunks and pencil-shaped fragments. Two-inch bed and one-foot bed of argillaceous siltstone 58 feet above base. 154.8 mileage marker below top of subunit. Storm drain about at base of unit. Thickness 93 feet.

Fossiliferous zones as noted: 182 feet below top (560 feet)—Bryozoa: *Fenestella* cf. *F. emaciata* (P); Brachiopoda: *Tropidoleptus carinatus* (P), *Devonochonetes scitulus* (C), *Mediospirifer audaculus* (C), *Spinocyrtia granulosa* (P), *Mucrospirifer mucronatus* (C); Pelecypoda; *Pterinopecten (Pseudaviculopecten) princeps* (P), *Modiomorpha concentrica* (P). 254 feet below top (488 feet)—Brachiopoda: *Tropidoleptus carinatus* (C), *Mucrospirifer mucronatus* (P). 266 feet below top (476 feet)—Brachiopoda: *Orbiculoidea doria?* (P), *Tropidoleptus carinatus* (VA), *"Chonetes"* sp. (C), *Mucrospirifer mucronatus* (A); Gastropoda: indet. gastropod sp. (P). 274 feet below top (468 feet)—Brachiopoda: *Rhipidomella vanuxemi* (P), *Tropidoleptus carinatus* (A), *Retichonetes marylandicus* (P), *R. vicinus* (C), *Cyrtina hamiltonensis* (P), *Delthyris sculptilis* (P), *Mucrospirifer mucronatus* (A); Gastropoda: *Crenistriella crenistria* (C), *Bembexia sulcomarginata?* (C); Trilobita: *Trimerus (Dipleura) dekayi* (P). 289 feet below top (453 feet)—Brachiopoda: *Devonochonetes coronatus* (A), *Mucrospirifer mucronatus* (VA). 301 feet below top (441

Unit		Unit Thickness	Cumulative Thickness

feet)—Brachiopoda: *Retichonetes marylandicus* (C), *Longispina mucronatus* (A), *Mucrospirifer mucronatus* (C). 305 feet below top (437 feet)—Brachiopoda: *Retichonetes marylandicus* (C), *Longispina mucronatus* (C), *Mucrospirifer mucronatus* (VA). 317 feet below top (425 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (C); Brachiopoda: *Tropidoleptus carinatus* (P), *Devonochonetes scitulus?* (C), *Longispina mucronatus* (A), *Mucrospirifer mucronatus* (VA); Pelecypoda: *Actinopteria decussata* (P), *Cornellites flabella* (P), *Nuculites lamellata?* (P), *Palaeoneilo constricta* (P); Trilobita: *Greenops boothi* (P); Echinodermata: crinoid columnals (A). 319 feet below top (423 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (P); Brachiopoda: *Orbiculoidea doria* (C), *Tropidoleptus carinatus* (A), *Longispina mucronatus* (P), *Mucrospirifer mucronatus* (VA); Pelecypoda: *Actinopteria* sp. (C), *Paracyclas lirata* (P); Gastropoda: *Ptomatis patulus* (P); Echinodermata: crinoid columnals (A). 395 feet below top (347 feet)—Brachiopoda: *Retichonetes marylandicus* (A), *Mucrospirifer mucronatus* (VA). 405 feet below top (337 feet)—Brachiopoda: *Tropidoleptus carinatus* (C), *Retichonetes marylandicus* (A), *Longispina mucronatus* (P), *Camarotoechia congregata* (P), *Spinocyrtia granulosa* (P). 416 feet below top (326 feet)—Brachiopoda: *Schuchertella variabilis* (P), *Tropidoleptus carinatus* (C), *Devonochonetes coronatus* (C), *"Chonetes"* sp. (P), *Retichonetes marylandicus* (VA), *Camarotoechia sappho* (P), *Spinocyrtia granulosa* (C); Pelecypoda: *Cornellites flabella* (P), cf. *Protomya oblonga* (P), *Nucula varicosa* (P), *Palaeoneilo perplana* (C), *Modiomorpha concentrica?* (P); Cephalopoda: *Spyroceras nuntium?* (P). 422 feet below top (320 feet)—Brachiopoda: *Retichonetes marylandicus* (A), *Longispina mucronatus* (P), *Mediospirifer audaculus* (A); Pelecypoda: *Actinopteria decussata* (P); Gastropoda: *Bembexia laevis* (C), *"Bembexia"* sp. (C). 441 feet below top (301 feet)—Brachiopoda: *Mediospirifer*

Unit		Unit Thickness	Cumulative Thickness
	audaculus (P). 472 feet below top (270 feet)—Pelecypoda: *Nucula bellistriata?* (P), *Palaeoneilo perplana?* (P). 476 feet below top (266 feet)—Brachiopoda: *Tropidoleptus carinatus* (C), *Longispina mucronatus* (C); Pelecypoda: *Palaeoneilo constricta* (P), *Modiomorpha concentrica* (P); Gastropoda: *Bembexia capillaria* (P). 480 feet below top (262 feet)—Brachiopoda: *Mediospirifer audaculus* (P); Pelecypoda: *Cornellites flabella* (P).	482	742
2.	Siltstone, medium-greenish-gray (5GY4/1) and medium-dark-gray (N4), weathering olive gray, in 3- to 48-inch commonly 8-inch beds. Fourteen-inch interbeds of silty shale form 15 percent of unit. 5 feet below top (255 feet)—Brachiopoda: *Tropidoleptus carinatus* (C); Pelecypoda: *Pterinopecten (Pseudaviculopecten) princeps?* (P); Gastropoda: *Bembexia sulcomarginata* (P). 29 feet below top (231 feet)—Brachiopoda: *Mediospirifer audaculus* (A); Echinodermata: crinoid columnals (C). 100 feet below top (160 feet)—Pteropoda?: *Tentaculites attenuatus* (P).	117	260
Gander Run Member			
3.	Claystone, silty, medium-gray, weathering olive gray, breaks into 1- to 2-inch irregular plates and pencil-shaped fragments. Three-inch nodules and one- to six-inch beds of siltstone, medium-gray, weathering yellowish gray (5Y7/2) and moderate yellowish brown (5YR5/2) form 20 percent of unit. One 20-inch siltstone 79 feet above base.	143	143

SUMMARY

Mahantango Formation	742′ exposed
Frame-Chaneysville Members	599′ exposed
Gander Run Member	143′ exposed

Section 14.—Section at Bedford

Two roadcuts on the northwestern side of the Pennsylvania Turnpike 4.2 miles west of the Bedford Interchange provide excellent exposures of the Gander Run and Frame Members of the Mahantango Formation. The section as described begins in the more northeasterly of the two cuts at the gradational contact of the Needmore Shale and the Marcellus Formation. A concealed interval of nearly 400 feet separates this exposure from the more southwesterly cut in which 253 feet of the Frame Member is exposed. Contact with the overlying calcareous Tully Member of the Harrell Formation is well exposed in this section.

On the Bedford, Pennsylvania Quadrangle, the base of the section is 8950 feet north of latitude 40°00′ N., and 1050 feet east of longitude 78°35′ W.

Units 1 through 3 of the Mahantango Formation are exposed in the more northwesterly cut. The cut on the southeastern side of the Turnpike here exposes beds below Unit 3 on the northern side, but this has not been included in the present study. Unit 5 of the Mahantango Formation, as well as the Marcellus and Needmore are exposed in the more northeasterly of the two roadcuts.

The *Tropidoleptus carinatus* Zone is in Unit 1 and the upper 3 feet of Unit 2; the *Mucrospirifer* and *Protoleptostrophia* Zonules, however, are not well defined, these species being common throughout the zone. This is the only exposed section of the uppermost part of the Frame Member in which the *Sulcoretepora* Zone is absent.

Unit		Unit Thickness	Cumulative Thickness
Harrell Formation			
Burket Member			
1.	Shale, fissile, black (N1).	31	48
Tully Member			
2.	Shale, calcareous, fissile, medium-gray (N5) to dark-gray (N3), weathering medium light gray (N6). Two-inch to one-foot beds of argillaceous limestone, medium-gray, weathering medium to light olive gray (5Y4/1) form 40 percent of unit. Contact with overlying Burket is gradational. Top defined by 1-foot limestone. Fossiliferous zones as noted: In limestone 2 feet below top (15 feet)—Brachiopoda: *Longispina mucronatus* (C), *Atrypa spinosa* (A), *Tylothyris pauliformis* (P), *"Spirifer"* sp. (P); Trilobita: *Phacops rana* (C). 9 feet below top (8 feet)—Brachiopoda: *Retichonetes? aurora* (P), *Ambocoelia umbonata*		

Unit	Unit Thickness	Cumulative Thickness
(VA). 13 feet below top (4 feet)—Brachiopoda: *Ambocoelia umbonata* (A), *Emmanuella pennsylvanica* (A).	17	17
Hamilton Group		
Mahantango Formation		
Frame Member		
Unit		
1. Shale, silty, medium-gray, weathering medium to light olive gray. Upper portion of unit is calcareous. One- to two-inch concretions of calcerous siltstone occur 17 to 26 feet above base. Fossiliferous zones as noted: 2 feet below top (1004 feet)—Brachiopoda: *Lingula* sp. (P), *Orbiculoidea doria* (C), *Protoleptostrophia perplana* (VA), *Schuchertella variabilis* (P), *Tropidoleptus carinatus* (A), *Devonochonetes scitulus* (P), *Mucrospirifer mucronatus* (A); Pelecypoda: *Nucula bellistriata* (C); Gastropoda: *Platyceras (platyostoma) euomphaloides* (C). 15 feet below top (991 feet)—Brachiopoda: *Protoleptostrophia perplana* (P), *Devonochonetes scitulus* (P), *Tylothyris pauliformis?* (P). 17 feet below top (989 feet)—Brachiopoda: *Protoleptostrophia perplana* (C), *"Chonetes" lepidus* (A), *Devonochonetes scitulus* (P), *"Spirifer" tullius* (P), *Mucrospirifer mucronatus* (C); Gastropoda: *Bucanopsis leda* (P). 27 feet below top (979 feet)—Brachiopoda: *"Chonetes" lepidus* (P), *Mucrospirifer mucronatus* (C); Pelecypoda: *Palaeoneilo constricta* (P), *Grammysioidea alveata* (P); Gastropoda: *Bucanopsis leda* (P). 40 feet below top (966 feet)—Brachiopoda: *Protoleptostrophia perplana* (P). 44 feet below top (962 feet)—Brachiopoda: *Tropidoleptus carinatus* (A); Pelecypoda: *Nucula bellistriata* (P). 57 feet below top (949 feet)—Brachiopoda: *Lingula* sp. (P), *Tropidoleptus carinatus* (A); Pelecypoda: *Nuclites oblongatus* (C), *Palaeoneilo constricta* (P); Gastropoda: *Bucanopsis leda* (P).	76	1006
2. Siltstone, micaceous, medium-greenish-gray (5GY5/1), in 2- to 6-inch beds. Interbeds of shale form nearly 50 percent of subunit. Thickness 20 feet.		
Siltstone, calcareous and argillaceous,		

Unit		Unit Thickness	Cumulative Thickness
	medium-gray, weathering medium greenish gray, in 6- to 10-inch beds. Thickness 20 feet. Fossiliferous 2 feet below top (928 feet)—Brachiopoda: *Rhipidomella vanuxemi* (A), *Protoleptostrophia perplana* (C), *Devonochonetes coronatus* (P), *Delthyris sculptilis* (A), *"Spirifer" tullius* (A), *Mucrospirifer mucronatus* (P); Trilobita: *Trimerus (Dipleura) dekayi* (C); Echinodermata: crinoid columnals.	40	930
3.	Shale, slightly silty, medium-olive-gray, weathering light olive gray. Two- to six-inch beds of siltstone, light-olive gray, form 25 percent of exposed unit, and are particularly prominent in upper half of unit. Fossiliferous 18 feet below top (872 feet—Brachiopoda: *"Spirifer" tullius* (P).	120	890
4.	Concealed.	377	770
Gander Run Member			
5.	Shale, argillaceous and silty, medium-gray and medium-olive-gray, weathering medium to light olive gray and rosy white. One-inch beds of calcareous siltstone occur with calcareous shale 20 to 30 feet above base. Overpass 125 feet below top (268 feet). 141.6 mileage marker 130 feet below top (273 feet). 141.7 mileage marker 342 feet below top (51 feet). Thickness 323 feet. Shale, medium-gray and dark-gray, weathering medium gray, breaks into small plates. Cleavage and faulting render bedding determination difficult. Thickness 70 feet. Fossiliferous 315 feet below top (78 feet)—Bryozoa: *Paleschara radiata* (A); Brachiopoda: *Productella truncata* (C), *Camarotoechia prolifica* (C), *Leiorhynchus limitare* (VA); Pelecypoda; *Leiopteria laevis* (A), *Leptodesma rogersi* (A); Gastropoda: *Bembexia sulcomarginata* (C), *Styliolina fissurella* (VA).	393	393
Marcellus Formation			
Unit			
1.	Shale, fissile, black, weathering dark gray. Faulted and cleaved. Contact with overlying Mahantango placed 51 stratigraphic feet (145 traverse feet) northeast of 141.7 mileage marker.	180	180

SUMMARY

Harrell Formation	48′ exposed
Burket Member	31′ exposed
Tully Member	17′
Mahantango Formation	1006′ exposed
Frame Member	120′ exposed
Chaneysville Member	
concealed	interval 377′
Gander Run Member	393′ exposed
Marcellus Formation	180′

Section 15.—Section at Fishertown

This section on the eastern limb of the Schellsburg dome is exposed in a roadcut and a large borrow pit along Route 56, 2700 feet southeast of Fishertown.

On the Bedford, Pennsylvania Quadrangle, the base of the described section is 13,200 feet north of latitude 40°05′ N., and 1600 feet east of longitude 78°35′ W.

In this section, differentiation of members is difficult, although Unit 5, a sequence of rather resistant siltstone, very likely represents the uppermost part of the Chaneysville Member to the south, or the Donation Member to the northeast, in Huntingdon County. Approximately one-third of the described section—largely concealed Unit 2—is concealed.

The Burket Member of the Harrell Formation and Unit 1 of the Mahantango Formation are poorly exposed along the bank of a dirt road leading south from Route 56 toward Springhope. Unit 3 is described from a small exposure on the northern side of Route 56, 365 traverse feet west of above mentioned intersection. Unit 4 is exposed in a large borrow pit on the northern side of Route 56; the lower 50 feet, however, are partially exposed along an old farm road parallel with, but above, Route 56. Units 5 and 6 are exposed west of the borrow pit in a roadcut on Route 56.

The faunal assemblages in the Fishertown section are not amenable to zonation corresponding with that further south. The fauna at 24 feet in Unit 6, with *Pustulatia pustulosa, Schuchertella variabilis, Phacops rana*, and numerous pelecypods looks convincingly like that of the *Sulcoretepora* Zone of the Frame Member but it is too far down in the section to be a correlative. The assemblage of *Rhipidomella, Protoleptostrophia*, and *Spinocyrtia* in Unit 5 is believed to represent a western extension of the *Delthyris-Spinocyrtia* fauna of the Donation Member at Huntingdon.

	Unit Thickness	*Cumulative Thickness*
Harrell Formation		
Burket Member		
Unit		
1. Shale, fissile, black (N1).	45	45
Hamilton Group		
Mahantango Formation		
Frame Member		
Unit		
1. Shale, argillaceous, dark-greenish-gray (5GY3/1). Exposed in bank on dirt road to Springhope.	6	532
2. Concealed. Shale and siltstone, medium-gray, loose in bank. Traverse distance from base of unit 1 to intersection of dirt road with Route 56 is 470 feet; from intersection to top of unit 3 is 365 feet.	136	526
3. Siltstone, calcareous, medium-dark-gray (N4), weathering dark yellowish brown (10YR4/2), in ½- to 2-inch beds, exposed along Route 56. Supports low ridge.	47	390
4. Claystone, silty and calcareous, medium-gray (N5), weathering medium to medium light olive gray (5Y5/1). Beds of argillaceous siltstone form 15 percent of lower fourth of unit. Nodules of calcareous siltstone from 59 feet above base to top of unit. Lower 20 to 25 feet of unit mostly covered. Unit exposed in large borrow pit. Fossiliferous zones as noted: Upper 20 feet (320 to 343 feet)—Brachiopoda: *Tropidoleptus carinatus* (C). Upper 169 feet (174 to 343 feet)—Brachiopoda: *Retichonetes vicinus* (C). 169 to 209 feet below top (134 to 174 feet)—Anthozoa: indet. horn coral (P), *Pleurodictyum styliporum* (P), auloporoid coral sp. no. 1 (C); Bryozoa: *Sulcoretepora* cf. *S. incisurata* (C); Brachiopoda: *Petrocrania hamiltoniae* (C), *Rhipidomella vanuxemi* (P), *Protoleptostrophia perplana* (P), *Devonochonetes coronatus?* (P), *D. scitulus* (P), *Retichonetes vicinus* (C), *Delthyris sculptilis* (P), *Mediospirifer audaculus* (P), *Spinocyrtia granulosa* (P), *Athyris spiriferoides* (C); Pelecypoda: *Orthonota undulata* (P), *Tellinopsis subemarginata* (P), *Nuculites oblongatus* (P), *Palaeoneilo constricta?* (P); Gastropoda: *Crenistriella crenistria* (P); Trilobita: *Trimerus (Dipleura) dekayi* (P), *Greenops boothi* (P); Echinodermata: crinoid columnals (C).	235	343

Unit	*Unit Thickness*	*Cumulative Thickness*
Chaneysville Siltstone Member		
5. Siltstone, calcareous and argillaceous, medium-gray, weathering light gray and light olive gray, in ½- to 2½-inch beds. Interbeds of shale form less than 10 percent of unit. Fossiliferous 13 to 20 feet below top (88-95 feet)—Anthozoa: *Pleurodictyum styloporum* (P); Bryozoa: *Fenestella* cf. *F. emaciata* (P); Brachiopoda: *Rhipidomella vanuxemi* (A), *Protoleptostrophia perplana* (C), *Schuchertella variabilis* (C), *Tropidoleptus carinatus* (C), *Longispina mucronatus* (A), *Delthyris sculptilis* (A), *Mediospirifer macronatus* (C), *Spinocyrtia granulosa* (C), *Athyris spiriferoides* (P); Pelecypoda: *Parallelodon hamiltonensis?* (P).	20	108
6. Shale, silty, medium-gray, weathering light to medium gray, breaks into 1- to 3-inch irregular plates. Unit somewhat calcareous from 9 feet above base to top. One- to four-inch beds of calcareous siltstone, medium-gray forms 5 percent of unit and is confined to lower third. Thickness 31 feet. Shale, silty, medium-olive-gray, weathering light olive gray. Two- to seventeen-inch beds of calcareous siltstone, medium-gray, lenticular and discontinuous, from 19 feet above base to top of unit. Road intersection and road marker 1/85 near top of subunit. Lower 20 to 25 feet of unit mostly covered. Thickness 57 feet. Fossiliferous zones as noted: 35 feet below top (53 feet)—Brachiopoda: *Retichonetes vicinus* (P), *Delthyris sculptilis?* (P). 64 feet below top (24 feet)—Anthozoa: indet. horn coral (P), zaphrentoid horn coral (P), *Pleurodictyum styloporum* (C), auloporoid coral sp. no. 1 (A); Brachiopoda: *Protoleptostrophia perplana* (P), *Schuchertella variabilis* (A), *Tropidoleptus carinatus* (P), *Devonochonetes scitulus* (P), *Longispina mucronatus* (A), *Pustulatia pustulosa* (P), *Delthyris sculptilis* (C), *Tylothyris pauliformis?* (C), *Athyris spiriferoides* (P), *Ambocoelia umbonata* (A); Pelecypoda: *Nucula* sp. (P), *Nuculites triqueter* (P), *Nuculana diversa* (P), *Palaeonielo constricta* (P), *P. muta* (C),		

Unit		Unit Thickness	Cumulative Thickness
	P. fecunda (P), *P. emarginata* (P), *Modiomorpha concentrica* (P); Gastropoda: *Bembexia capillaria* (P), *B. sulcomarginata* (A), *Platyceras* sp. (C), indent. gastropod sp. (A), *Loxonema delphicola* (C); Cephalopoda: *Striacoceras typum?* (A); Pteropoda?: *Tentaculites attenuatus* (P); Trilobita: *Phacops rana* (P); Ostracoda: ostracode sp. (P); Echinodermata: crinoid columnals (VA).	88	88

SUMMARY

Harrell Formation	45′
Burket Member	45′
Mahantango Formation	532′ exposed
Frame Member	424′
Chaneysville Siltstone Member	108′ exposed

Section 16.—Section at Huntingdon

Along U. S. Route 22 on the southwestern side of the Juniata River opposite Huntingdon is the most complete and best exposed section of the Mahantango Formation examined in south-central Pennsylvania during the present study. The base of the described section is at the most northerly exposure of the Marcellus Formation on the northeastern side of Route 22, just south of the cloverleaf intersection with Pennsylvania Route 26. On the Huntingdon, Pennsylvania Quadrangle, the base of the section is 4800 feet south of latitude 40°30′ N., and 14,300 feet east of longitude 78°05′ W.

The upper part of the Marcellus Formation, and Units 11 and 12 of the Gander Run Member of the Mahantango Formation are exposed in a large, presently active borrow pit on the southwestern side of the highway. The lower part of Unit 10 is exposed along a dirt road leading west from the highway near a Sinclair gas station, and across from a State Police building. The upper part of Unit 10 is exposed behind a few buildings and along Route 22 on the southwestern side. The Backbone Ridge Member (Unit 9) is exposed in the large roadcut on both sides of the road. This unit is resistant enough to support a ridge traceable for several miles north and south of Huntingdon. Units 7 and 8 of the Crooked Creek Member also are exposed on either side of Route 22 in the large roadcut. Unit 6 is a concealed interval, including a concrete bridge that passes over a railroad and secondary road below. The Donation Member (Unit 5) is exposed only on the southwestern

side of the highway, and, like the Backbone Ridge Member, supports a thin ridge traceable for some distance along the strike beyond Huntingdon. Unit 4 is a concealed interval within which a concrete bridge passes over a small stream. Unit 3, representing the lower part of the Frame Member is exposed along a secondary road leading from Route 22 opposite a diner, southwestward along the northwest flank of Piney Ridge. This unit is poorly exposed in the gutter and in the bank on the uphill side of Piney Ridge road about one mile southwest of Route 22. Units 1 and 2 of the Mahantango Formation, as well as the Burket and Tully Members of the Harrell Formation, are exposed in a large borrow pit on the southwestern side of Route 22, just north of a gas station. The top of the Burket Member is exposed behind this same gas station. In all, about 35 percent of the described section of the Mahantango Formation is concealed here at Huntingdon. The section also is particularly useful in that both the upper and lower contacts of the Mahantango are exposed.

Faunal zones of the Mahantango Formation are distributed in the described units as follows:

Sulcoretepora cf. *S. incisurata* Zone—922 to 952 feet—(Unit 1)
Tropidoleptus carinatus Zone—829 to 836 feet—(Unit 3)
Mediospirifer audaculus Zone—212 to 260 feet—(Units 8 and 9)

In addition to these assemblage zones, several faunas, of local use in mapping, have been recognized in Units 5 through 10 (See figure 6).

Harrell Formation
Burket Member

Unit	*Unit Thickness*	*Cumulative Thickness*
1. Shale, fissile, black (N1). Fossils noted: Pelecypoda: *Buchiola retrostriata* (C); Pteropoda?: *Styliolina fissurella* (C).	57	62
Tully Member		
2. Shale, silty, medium-gray (N5), weathering medium to light brownish gray. Concretions of silty limestone, medium-gray, 3 inches thick, 8 inches in diameter, common 4 feet below top. Fossils noted: Brachiopoda: *Schuchertella variabilis* (C), *Leiorhynchus mesacostale?* (P), *Hypothyridina venustula?* (C), *Atyrpa reticularis* (P), *Emmanuella subumbona?* (A), *Echinocoelia ambocoeloides* (C); Pelecypoda: *Cypricardinia indenta* (P), nautiloid sp. (P); Pteropoda?: *Styliolina fissurella* (A); Trilobita: *Deche-*		

Unit	Unit Thickness	Cumulative Thickness
nella (Monodechcnella) macrocephala (P); Ostracoda: ostracode sp. (C).	5	5

Hamilton Group

Mahantango Formation

Frame Member

1. Shale, silty, medium-gray, weathering olive gray (5Y4/1). Thickness 6 feet.
   Claystone, silty, medium-gray, weathering medium gray, breaks into small irregular fragments. Concretions up to 5 inches thick and lenticular beds up to 18 inches thick of silty limestone, medium-light-gray (N6), abundant along with muscovite flakes and pyrite from 19 feet above base to top. Thickness 61 feet.
   Fossiliferous zones as noted: 7 feet below top (952 feet)—Bryozoa: *Fcncstella* cf. *F. emaciata* (A), *F.* cf. *F. sinuosa* (A), *Polypora* sp. (C), *Sulcoretepora* cf. *S. incisurata* (A), *Taeniopora exigua* (C), fistuliporoid bryozoan (A); Brachiopoda: *Craniops hamiltoniae* (P), *Tropidolcptus carinatus* (P), *Camarotocchia* sp. (P), *Schuchertella variabilis* (A), *Douvillina inaequistriata* var. *immatura* (C), *Atrypa reticularis* (P), *Ambocoelia umbonata* (P); Trilobita: *Phacops rana* (A); Ostracoda: *Euglyphclla* sp. (P), *Adclphobolbina mcdialis* (P), *Hollinella* sp. (P), ostracode spp. (C); Echinodermata: crinoid columnals. 7 to 12 feet below top (947 to 952 feet)—Anthozoa: *Heliophyllum halli* (C), *Hetcrophrentis* cf. *H. simplex* (P), *Blothrophyllum* cf. *B. conatum* (P), *"Cystiphyllum"* cf. *C. varians* (P), *Favosites* sp. 1 (P), *Favosites* sp. 2 (P); Bryozoa: *Fencstella* cf. *F. emaciata* (A), *F.* cf. *F. sinuosa* (C), *Polypora* cf. *P. celsipora* (P), *Polypora* sp. (P), *Sulcoretepora* cf. *S. incisurata* (A), *Sulcorctepora*? sp. (C), *Taeniopora exigua* (C), fistuliporoid bryozoan (C); Brachiopoda: *Craniops hamiltoniae* (C), *Rhipidomella vanuxemi* (P), *Tropidoleptus carinatus* (C), *Camarotoechia sappho* (C), *Schuchertella variabilis* (A), *Douvillina inaequistriata* (P), *D. inaequistriata* var. *immatura* (A), *Elytha fimbriata* (P), *Pustulatia pustulosa* (C), *Tylothyris pauli-*

Unit		Unit Thickness	Cumulative Thickness

formis (C), *Ambocoelia umbonata* (C); Pelecypoda: *Cypricardinia indenta* (P), *Nucula bellistriata*? (P), *Palaeoneilo constricta* (P), *P. muta* (P), *P. tenuistriata* (P), *Goniophora hamiltonensis*? (P), *Grammysia arcuata* (P), *Actinopteria decussata* (C); Pteropoda?: *Styliolina* sp. (P); Conularida: *Conularia* sp. (P); Trilobita: *Trimerus (Dipleura) dekayi* (P), *Proetus rowi* (P); Ostracoda: *Hillinella tricollina* (P), *H.* cf. *H. sella* (P), *Adelphobolbina medialis* (C), *Ctenoloculina cicatricosa* (P), *Ulrichia spinifera* (C), *Hibbardia lacrimosa* (C), *Quasillites* sp. (P), ostracoda spp. (A); Echinodermata: *Tcchnocrinus*? sp. (P), crinoid columnals (A). In limestone, between 7 and 12 feet below top (947 to 952 feet)—Bryozoa: *Sulcoretepora* sp. (C); Brachiopoda: *Camarotoechia* sp. (P), *Protoleptostrophia perplana* (P), *Douvillina inaequistriata* (P), *Devonochonetes scitulus* (A), *Longispina mucronatus* (A), *Mucrospirifer mucronatus* (C), *"Spirifer" tullius* (C); Pelecypoda: *Nucula bellistriata* (P), *Nuculites oblongatus* (C), *N.* sp. (P), *Aviculopecten insignis* (P); Gastropoda: *Bembexia capillaria*? (C); Trilobita: *Greenops boothi* (P), *Proetus rowi* (C), *Dechenclla (Monodechenella) macrocephala* (P). 12 to 17 feet below top (942 to 947 feet)—Bryozoa: *Fenestella* sp. (C), *Sulcoretepora* cf. *S. incisurata* (A); Brachiopoda: *Craniops hamiltoniae* (P), *Camarotoechia congregata* (C), *Schuchertella variabilis* (A), *Protoleptostrophia perplana* (C), *"Chonetes" lepidus* (C), *Truncalosia truncata* (P), *Pustulatia pustulosa* (A), *Delthyris sculptilis* (A), *Ambocoelia umbonata* (P); Pelecypoda: *Cypricardinia indenta* (P); Gastropoda: *Bembcxia capillaria*? (P); Pteropoda?: *Tentaculites attenuatus* (P); Trilobita: *Trimerus (Dipleura) dekayi* (P), *Greenops boothi* var. *calliteles* (P); Ostracoda: *Hollinella* sp. (C), *Hibbardia lacrimosa* (C), *Ponderodictya punctulifera* (C), *Euglypliella* sp. (C); Echinodermata: crinoid columnals (A). 17 to 22 feet below top (937 to 942 feet)—Anthozoa: *Thamnopora* sp. 1

Unit		*Unit Thickness*	*Cumulative Thickness*
	(P), thamnoporoid coral (P), zaphrentoid coral (C), auloporoid coral (A); Bryozoa: *Fenestella* cf. *F. emaciata* (A), *F.* cf. *F. sinuosa* (A), *Polypora* cf. *P. celsipora* (A), *Sulcoretepora* cf. *S. incisurata* (A), *Sulcoretepora?* sp. (C), fistuliporoid bryozoan (C); Brachiopoda: *Craniops hamiltoniae* (P), *Rhipidomella vanuxemi* (P), *Tropidoleptus carinatus* (C), *Camarotoechia* sp. (P), *Schuchertella variabilis* (C), *Protoleptostrophia perplana* (C), *Douvillina inaequistriata* (P), *D. inaequistriata* var. *immatura* (C), *"Chonetes" lepidus* (C), *"Chonetes"* sp. (P), *Delthyris sculptilis* (A), *Elytha fimbriata* (C), *Mucrospirifer mucronatus* (P), *Atrypa reticularis* (P), *Ambocoelia umbonata* (C), *Cyrtina hamiltonensis* (P), *Athyris spiriferoides?* (P); Pelecypoda: *Orthonota undulata?* (P) *Palaeoneilo muta* (P), *P. emarginata* (P), *Actinopteria decussata* (C), *Cypricardinia indenta* (P), *Conocardium concinnum* (P); Gastropoda: *Bucanopsis leda?;* Trilobita: *Phacops rana* (P), *Greenops boothi* (C), *G. boothi* var. *calliteles* (P); Ostracoda: *Hollinella* sp. (C), *Adelphobolbina medialis* (A), *Hibbardia lacrimosa* (P), *Ponderodictya punctulifera* (C); Echinodermata: crinoid columnals (A). 37 feet below top (922 feet)—Bryozoa: *Fenestella* cf. *F. emaciata* (C), *Sulcoretepora* cf. *S. incisurata* (A), indet. bryozoan sp. (P); Brachiopoda: *Camarotoechia congregata* (P), *Protoleptostrophia perplana* (P), *Schuchertella variabilis* (P), *Douvillina inaequistriata* var. *immatura* (C), *Devonochonetes scitulus* (C), *Longispina mucronatus* (C), *Delthyris sculptilis* (P), *Mediospirifer audaculus* (P), *Mucrospirifer mucronatus* (C), *Ambocoelia umbonata* (P); Pelecypoda: *Actinopteria decussata* (P), *Pterinopecten* sp. (P); Cephalopoda: *Spyroceras nuntium?* (P); Trilobita: *Trimerus (Dipleura) dekayi* (P); Ostracoda: *Euglyphella* sp. (P), ostracode sp. (A); Echinodermata: crinoid columnals (A). 42 feet below top (917 feet)—Brachiopoda: *Devonochonetes scitulus* (P), *Longispina mucronatus* (C), *"Spirifer" tullius*		

Unit		Unit Thickness	Cumulative Thickness
	(C), *Mucrospirifer mucronatus* (C); Pelecypoda: *Orthonota undulata* (P), *Nuculites triqueter* (P), *Palaeoneilo plana* (P), *Grammysia arcuata* (P); Gastropoda: *Cyclonema* sp. (P); Trilobita: *Trimerus (Dipleura) dekayi* (P). 52 feet below top (907 feet)—Brachiopoda: *Devonochonetes scitulus* (C). 57 feet below top (902 feet)—Brachiopoda: *Protoleptostrophia perplana* (P), *Devonochonetes scitulus* (A), *"Spirifer" tullius* (C), *Mucrospirifer mucronatus* (A); Pelecypoda: *Nucula bellistriata* (C), *Nuculites triqueter* (P), *N. oblongatus* (P), *Grammysia arcuata* (P); Gastropoda: *Bembexia capillaria* (C), indet. gastropod sp. (P); Cephalopoda: *Striacoceras typum?* (P); Conularida: *Conularia* sp. (P); Trilobita: *Greenops boothi* (P).	67	959
2.	Siltstone, slightly calcareous, medium-gray, weathering medium dark yellowish brown (10YR4/2), in 1- to 20-inch beds that are finely laminated and cross-laminated with darker gray laminae. Four-inch beds of fine-grained sandstone, medium-gray, form 20 percent of unit. Slightly silty shale, medium-greenish-gray (5GY5/1), weathering olive gray, forms nearly 40 percent of unit.	18	892
3.	Claystone, silty, medium-greenish-gray, weathering olive gray, breaks into elongate, hackly fragments. Exposed along Piney Ridge road. Thickness 33 feet. Claystone, very silty, and siltstone, argillaceous, medium-greenish-gray, weathering olive gray, breaks into small hackly fragments. Unit becomes slightly calcareous 17 feet below top. Two-foot bed of calcareous siltstone marks top of unit. Exposed along Piney Ridge road. Thickness 27 feet. Claystone, silty, medium-greenish-gray, weathering olive gray, breaks into elongate hackly fragments. One-to two-inch subspherical nodules of siltstone common, especially in lower half of exposed unit. Exposed along Piney Ridge road. Thickness 40 feet. Fossiliferous 38 to 45 feet below top (829 to 836 feet)—Brachiopoda: *Tropidoleptus carinatus* (A), *Schuchertella variabilis* (P), *Protoleptostrophia perplana* (P), *"Spirifer"*		

Unit		Unit Thickness	Cumulative Thickness
	sp. (P); Pelecypoda: *Grammysia arcuata* (P), *Pterinopecten (Pseudaviculopecten) princeps* (C); Gastropoda: *Bembexia capillaria* (P), *B.* sp. (C); Echinodermata: crinoid columnals (C).	100	874
4.	Concealed. Probably part of the Frame Member. Bridge over small stream near base of concealed interval.	87	774
Donation Member			
5.	Siltstone, argillaceous, medium-gray, weathering olive gray, in 2- to 8-foot beds. Unit is calcareous and more argillaceous toward top. One- to five-inch nodules and lenticular, discontinuous beds of calcareous siltstone present in lower half of subunit. Surface of freshly exposed portion of upper part of subunit is grayish red. Thickness 64 feet. Siltstone, medium-gray, weathering dark yellowish brown, in 2- to 14-inch beds. Three- to nineteen-inch beds of silty claystone, medium-gray, weathering olive gray, form 70 percent of subunit. Thickness 12 feet. Fossiliferous zones as noted: 15 feet below top (672 feet)—Bryozoa: *Fenestella* sp. (C); Brachiopoda: *Schuchertella variabilis* (P), *Douvillina inaequistriata* var. *immatura* (P); Pelecypoda: *Phthonia sectifrons?* (P); Echinodermata: crinoid columnals (A). 21 feet below top (666 feet)—Anthozoa: auloporoid coral sp. (A); Brachiopoda: *Schuchertella variabilis* (C), *Pholidostrophia pennsylvanica* (P), *Devonochonetes scitulus* (C), *Delthyris sculptilis* (P); Echinodermata: crinoid columnals (A). 26 feet below top (661 feet)—Anthozoa: auloporoid coral sp. (P); Bryozoa: *Fenestella* cf. *F. emaciata* (C), *Sulcoretepora* cf. S. *incisurata* (C), *Taeniopora exigua* (A); Brachiopoda: *Camarotoechia sappho* (C), *Delthyris sculptilis* (A), *Elytha fimbriata* (C), *"Spirifer"* sp. (P), *Athyris spiriferoides?* (P); Pelecypoda: *Goniophora* sp. ? (P); Echinodermata: crinoid columnals (A). 29 feet below top (658 feet)—Brachiopoda: *Rhipidomella vanuxemi* (C), *Spinocyrtia granulosa* (P). 38 to 39 feet below top (648 to 649 feet)—Brachiopoda: *Rhipidomella vanuxemi* (A), *Protoleptostrophia perplana* (P), *Douvillina*		

Unit		Unit Thickness	Cumulative Thickness
	inaequistriata (P), *Mediospirifer audaculus* (P), *Mediospirifer? angustus* (P). 49 feet below top (642 feet)—Anthozoa: *Pleurodictyum styloporum* (A); Brachiopoda: *Rhipidomella vanuxemi* (A), *Schuchertella variabilis* (A), *Spinocyrtia granulosa* (C); Echinodermata: crinoid columnals (A).	76	687
Crooked Creek Member			
6.	Concealed. Probably part of Crooked Creek Member. Bridge on Route 22 passes over railroad and secondary road in this interval.	250	611
7.	Shale, silty, medium-gray, weathering olive gray and moderate yellowish brown, breaks into small plates and splintery fragments. One-half to 24-inch concretions of calcareous siltstone common in lower 9 feet of unit, and upper 19 feet of unit where they are fewer but larger than those below. Siltstone and calcareous siltstone form 20 percent of lower 8 feet. Fossiliferous zones as noted: In talus near top of unit—Brachiopoda: *Longispina mucronatus* (P), *Pustulatia pustulosa* (C), Gastropoda: *Bembexia sulcomarginata* (C); Cephalopoda: orthocerid sp. (P); Ostracoda: ostracode sp. (P). 34 feet below top (327 feet)—Brachiopoda: *Camarotoechia prolifica* (C), *Leiorhynchus multicostum* (A), *Devonochonetes scitulus* (C); Pelecypoda: *Nucula varicosa* (P), *Nuculites oblongatus* (C); Gastropoda: *Mourlonia itys* (P).	45	361
8.	Claystone, silty, medium-gray to medium-greenish-gray, weathering olive gray, breaks into irregular fragments. Concretions of calcareous siltstone, less than 1 inch in diameter, from 38 to 42 feet below top. Two-inch to four-inch lenticular concretions 8 to 38 feet below top. Thickness 60 feet. Claystone, silty, slightly calcareous, medium-gray to medium-greenish-gray, weathering olive gray and moderate brown, in 3- to 5-foot beds. Subunit less silty toward top. Thickness 19 feet. Fossiliferous zones as noted: 33 feet below top (283 feet)—Brachiopoda: *Spinocyrtia granulosa clintoni* (A); Pelecypoda: *Orthonota undulata* (P), *Modiomorpha concentrica* (C), *Goniophora hamiltonensis* (P);		

Unit		Unit Thickness	Cumulative Thickness
	Gastropoda: *Bembexia sulcomarginata* (A); Cephalopoda: *Spyroceras nuntium?* (P). 52 feet below top (264 feet)—Brachiopoda: *Tropidoleptus carinatus* (C); Gastropoda: *Bembexia sulcomarginata* (P). 56 feet below top (260 feet)—Brachiopoda: *"Chonetes"* sp. (P), *Mediospirifer audaculus* (C).	79	316
Backbone Ridge Member			
9.	Siltstone, argillaceous and calcareous, medium- to dark-grayish-red (5R3/2), weathering medium light grayish red (5R6/2) and olive gray, in 1- to 2-foot beds that are partly laminated. Unit becomes increasingly argillaceous toward base which is placed at a 1- to 5-inch bed of calcareous siltstone that is 71 traverse feet south of larger of two storm drains. Another 1- to 8-inch bed of calcareous siltstone is 7 feet above base. Contact with underlying unit is gradational. Fossiliferous zones as noted: 4 feet below top (233 feet)—Brachiopoda: *Protoleptostrophia perplana* (C), *Devonochonetes coronatus* (P), *Longispina mucronatus* (P); Pelecypoda: *Actinopteria decussata* (P); Gastropoda: *Bembexia sulcomarginata?* (P). 15 to 25 feet below top (212 to 222 feet)—Anthozoa: *Pleurodictyum styloporum* (C); Brachiopoda: *Devonochonetes coronatus* (P), *Mediospirifer audaculus* (C). In talus—Brachiopoda: *Camarotoechia* sp. (A), *"Chonetes"* sp. (C), *Mediospirifer audaculus* (C); Echinodermata: crinoid columnals (C).	45	237
Gander Run Member			
10.	Claystone, silty and calcareous, medium- and medium-dark-gray, weathering olive gray and medium light gray. One 13-inch and one 4-inch bed of calcareous siltstone 34 and 32 feet below top respectively. Claystone is not calcareous beneath 31 feet below top, becomes increasingly silty and less fissile toward top. Lower part of unit exposed along secondary dirt road leading west from Route 22. Upper part of unit exposed behind buildings and along Route 22. Fossiliferous zones as noted: 5 to 10 feet below top (182 to 187 feet)—Bryozoa:		

Unit		Unit Thickness	Cumulative Thickness
	Sulcoretepora cf. *S. incisurata* (C); Brachiopoda: *Rhipidomella vanuxemi* (C), *Devonochonetes scitulus* (C), *Longispina mucronatus* (C), *Mediospirifer audaculus* (P); Pelecypoda: *Nuculites oblongatus* (P), *Leiopteria laevis* (P); Echinodermata: crinoid columnals (C). 26 feet below top (166 feet)—Bryozoa: *Sulcoretepora* cf. *S. incisurata* (P), *Paleschara radiata* (C); Brachiopoda: *Camarotoechia prolifica* (C). 36 feet below top (156 feet)—Bryozoa: *Paleschara radiata* (C); Brachiopoda: *Leiorhynchus limitare* (A); Pelecypoda: *Leptodesma rogersi* (A).	59	192
11.	Shale, very slightly silty, weathered olive gray. Laminae of fossiliferous siltstone, but specimens unidentifiable. Unit exposed at top of borrow pit and along adjacent dirt road.	30	133
12.	Claystone, dark-olive-gray (5Y3/1), weathering medium light greenish brown, medium light reddish brown, and light gray, breaks into plate- and pencil-shaped fragments about 1 inch across. Light, almost white weathered surface of fragments. Two-inch black shale 2 feet above base of exposure. One- to four-foot bed of calcareous siltstone, medium-purplish-gray, weathering olive gray and moderate to dark yellowish brown, breaks into ½- to 3-foot blocks, 47 feet above base of unit. Exposed in large, active borrow pit. In talus at about 42 feet: indet. pelecypod sp. (VA).	103	103
Marcellus Formation			
1.	Shale, fissile, black, weathering medium-dark-gray. One-foot lenticular limestone at 200 feet is underlain by 8 feet of calcareous shale. Exposed on both sides of highway. Upper part on western side. Concrete culvert (rain gutter) near top of exposure on western side. Concealed from 239 to 385 feet. *Leiorhynchus limitare* (A).	397	397

SUMMARY

Harrell Formation	62′
Burket Member	57′
Tully Member	5′

Mahantango Formation	959′
Frame Member	272′ exposed
Donation Member	76′ exposed
Crooked Creek Member	374′
Backbone Ridge Member	45′
Gander Run Member	192′
Marcellus Formation	397′ exposed

Section 17.—Section at Martin Gap

This section, on the eastern limb of the Broadtop synclinorium, near its nose, is exposed along a dirt road and in the large borrow pit at Martin Gap, in Miller Township, Huntingdon County, Pennsylvania. The base of the described section is at the eastern end of the borrow pit, on the northern side of the road, at a point 3700 feet south of latitude 40°35′ N., and 4750 feet west of longitude 77°50′ W., in the Allensville, Pennsylvania Quadrangle.

Neither the bottom nor the top of the Mahantango Formation is exposed here, but the sequence of Gander Run (Unit 5) and Backbone Ridge (Unit 4) Members and the lower part of the Crooked Creek Member (Unit 3) is rather well displayed in the borrow pit. The upper part of the described section (Unit 1) has been referred to the Donation Member on the basis of its fauna which is nearly identical to that of the Donation Member at Huntingdon. Structural complexity is suggested by the nearly vertical attitude of Unit 1, in contrast with the attitude of the units in the borrow pit, where the beds dip to the northwest at an angle of 45 degrees.

Faunal zones are distinguished in units in the Martin Gap section as follows:

Mediospirifer audaculus Zone
Longispina fauna—Unit 3
Leiorhynchus limitare fauna—Unit 4? and Unit 5

Fossiliferous horizons in Unit 4 (208, 212, and 231 feet) contain species such as *Paleschara radiata* and *Leptodesma rogersi* that are suggestive of the *Leiorhynchus* fauna.

Hamilton Group
Mahantango Formation
Donation Member?
Unit

1. Claystone, silty, weathering medium-olive-gray (5Y4/1) and medium-light-gray (N6), breaking into plates commonly one-half to

Unit		Unit Thickness	Cumulative Thickness
	2 inches across. Siltstone, weathering dark yellowish brown (10YR4/2), in six beds averaging 2½ inches thick forms 20 percent of sequence between 62 and 68 feet below top (539 to 545 feet). Fossiliferous zones as noted: 45 feet below top (562 feet)—Bryozoa: *Fenestella* cf. *F. emaciata* (A), *Sulcoretepora* cf. *S. incisurata* (A), *Taeniopora exigua* (A); Brachiopoda: *Lingula ligea*? (P), *Rhipidomella vanuxemi* (C), *Douvillina inaequistrata* (C), *Pholidostrophia pennsylvanica* (P), *Schuchertella variabilis* (C), *"Chonetes"* sp. (C), *Longispina mucronatus* (P), *Camarotoechia prolifica* (P), *Camarotoechia sappho* (C), *Atrypa reticularis* (C), *Delthyris sculptilis* (C), *Tylothyris pauliformis* (P), *Elytha fimbriata* (C), *Spinocyrtia granulosa* (C), *Amboccelia umbonata* (P); Trilobita: *Dechenella (Monodechenella) macrocephala* (C); Ostracoda: *Hibbardia lacrimosa* (C); Echinodermata: crinoid columnals (VA). 56 feet below top (551 feet)—Bryozoa: *Fenestella* cf. *F. sinuosa* (P), *Fenestella* cf. *F. emaciata* (C), *Taeniopora exigus* (C); Brachiopoda: *Rhipidomella vanuxemi* (C), *Tropidoleptus carinatus* (P), *Longispina mucronatus* (P), *Delthyris sculptilis* (P), *Mediospirifer audaculus* (P); Pelecypoda: *Cypricardella bellastriata* (P); Trilobita: *Dechenella (Monodechenella) macrocephala* (P); Echinodermata: crinoid columnals (VA).	135	607
2.	Concealed interval.	119	472
Crooked Creek Member?			
3.	Claystone, silty, calcareous, medium-olive-gray (5Y4/1), weathering medium gray (N5) to medium grayish brown, breaks into small irregular pencil-shaped fragments and small plates. Concretion and one 3-inch bed of siltstone, calcareous, medium-gray (N5) between 50 and 54 feet below top (299 to 303 feet). Fossiliferous zones as noted: 37 feet below top (316 feet)—Brachiopoda: *Retichonetes marylandicus* (P); Echinodermata: crinoid columnals (A). 80 feet below top (273 feet)—Brachiopoda: *Protoleptostrophia perplana* (P), *Tropidoleptus*		

Unit		Unit Thickness	Cumulative Thickness
	carinatus (A), "*Chonetes*" sp. (P), *Longispina mucronatus* (C), *Spinocyrtia granulosa* (P); Pelecypoda: *Aviculopecten bellus* (P), *Leptodesma rogersi* (P); Trilobita: *Greenops boothi*? (P). 88 feet below top (265 feet)—Brachiopoda: *Devonochonetes scitulus* (P).	113	353
Backbone Ridge Member			
4.	Interbedded silty claystone and siltstone, argillaceous and calcareous, dark-olive-gray (5Y3/1), weathering medium gray. Unit is increasingly argillaceous toward base. Four- to twelve-inch beds of calcareous siltstone, medium-gray, mark base of unit. Top of unit gradational and, therefore, arbitrary. Fossiliferous zones as noted: 9 feet below top (231 feet)—Bryozoa: *Paleschara radiata* (A); Brachiopoda: *Productella spinulicosta* (P), *Camarotoechia prolifica* (A); Trilobita: *Greenops boothi* (P). 28 feet below top (212 feet)—Bryozoa: *Paleschara radiata* (A); Brachiopoda: *Productella spinulicosta* (P), *Camarotoechia prolifica* (A); Pelecypoda: indet. pelecypod sp. (P); Trilobita: *Trimerus (Dipleura) dekayi* (P). 32 feet below top (208 feet)—Brachiopoda: *Camarotoechia prolifica* (C); Pelecypoda: *Prothyris lanceolata*? (P), *Leptodesma rogersi*? (P).	60	240
Gander Run Member			
5.	Claystone, slightly silty, dark-olive-gray, weathering medium gray and medium light gray, breaks into pencil-shaped fragments up to 6 inches long. Three-inch disc-shaped nodules of calcareous claystone, 157 feet below top. Twenty-inch bed of siltstone, medium-gray, weathering dark yellowish brown, 127 feet below top. Fossiliferous zones as noted: 24 feet below top (156 feet)—Bryozoa: *Paleschara radiata* (P); Brachiopoda: "*Chonetes*" sp. (P), *Leiorhynchus limitare* (A); Pelecypoda: *Conocardium normale*? (P), *Nucula bellistriata* (P), *Nuculites oblongatus* (C), *Palaeoneilo constricta* (P), *P. perplana*? (P), *Prothyris lanceolata* (C), *Grammysia bisulcata* (P); Cephalopoda: orthocerid sp. (P). 31 feet below top (149 feet)—Brachiopoda: *Camaro-*		

Unit	*Unit Thickness*	*Cumulative Thickness*
toechia prolifica (P), *Leiorhynchus limitare* (A); Pelecypoda: *Aviculopecten* sp. (P), *Leptodesma rogersi* (P); Cephalopoda: *Michelinoceras? subulatum* (P).		
SUMMARY	180	180
Mahantango Formation 607′ exposed		
Donation Member? 254′ exposed		
Crooked Creek Member? 113′ exposed		
Backbone Ridge Member 60′		
Gander Run Member 180′ exposed		

Section 18.—Section at Newry

This section, in Bald Eagle Valley along U. S. Route 220, 0.8 mile south of the village of Newry, exposes the uppermost part of the Mahantango Formation, as well as the Tully Member and part of the Burket Member of the Harrell Formation. All of these units are exposed in one continuous roadcut on both sides of the highway on the crest of a hill south of Newry.

The section is located 12,700 feet south of latitude 40°25′ N., and 4750 feet west of Longitude 78°25′ W. in the west-central rectangle of the Hollidaysburg, Pennsylvania Quadrangle.

The upper part of the Frame Member (Units 1 and 2) of the Mahantango Formation is well exposed in this section. None of the described section is concealed. In Unit 1, the *Sulcoretepora* Zone is represented by fossiliferous horizons from 65 to 67 feet above the base of the section; the *Tropidoleptus* Zone is represented by assemblages dominated by that species in Unit 2.

Harrell Formation

Tully Member

Unit	*Unit Thickness*	*Cumulative Thickness*
1. Limestone, argillaceous, medium-gray (N5), weathering medium light gray (N6) and moderate yellowish brown (10YR5/4) near top. Calcareous claystone forms nearly 50 percent of unit. Fossiliferous—Brachiopoda: *Hypothyridina venustula* (P), *Retichonetes aurora* (P), *Emmanuella pennsylvanica* (A), *Ambocoelia umbonata* (P); Gastropoda: *Platyceres (Orthonychia) conicum?* (P).	3	3

Unit	*Unit Thickness*	*Cumulative Thickness*

Hamilton Group
Mahantango Formation
Frame Member
Unit

1. Claystone, argillaceous, medium-greenish-gray (5GY5/1), weathering light olive gray (5Y5/2). Calcareous claystone, medium-gray and medium-bluish-gray (5B5/1). Concretions, as large as 1 foot thick and 3 feet in diameter, of silty limestone, 41, 44, and 54 feet below top. One-foot thick lenticular bed of silty limestone 40 feet below top of unit. Fossiliferous zones as noted: In limestone 5 feet below top (70 feet)—Bryozoa: *Polypora* sp. (C); Brachiopoda: *Tropidoleptus carinatus* (P), *"Chonetes" lepidus* (P), *Mucrospirifer mucronatus* (A). 6 feet below top (69 feet)—Brachiopoda: *Rhipidomella vanuxemi* (P), *Protoleptostrophia perplana* (P), *Douvillina inaequistriata* var. *immatura* (A), *Tropidoleptus carinatus* (A), *Atrypa spinosa* (P), *Mediospirifer audaculus* (A), *Mucrospirifer mucronatus* (P); Trilobita: *Phacops rana* (P); Echinodermata: crinoid columnals (A). 8 to 9 feet below top (66 to 67 feet)—Anthozoa: indet. horn coral (C); Bryozoa: fistuliporoid bryozoan (P), *Sulcoretepora* cf. *S. incisurata* (A), *Taeniopora exigua* (P); Brachiopoda: *Protoleptostrophia perplana* (P), *Douvillina inaequistriata* var. *immatura* (P), *Tropidoleptus carinatus* (P), *Devonochonetes coronatus* (C), *"Chonetes" lepidus* (C), *Devonochonetes scitulus* (C), *"Spirifer" tullius* (C), *Mucronatus mucronatus* (A), *Amborcoelia umbonata* (C); Pelecypoda: *Cypricardella bellastriata* (P), *Grammysia arcuata* (P); Echinodermata: crinoid columnals (A). 10 feet below top (65 feet)—Anthozoa: indet. horn coral (P); Bryozoa: *Sulcoretepora* cf. *S. incisurata* (P); Brachiopoda: *Protoleptostrophia perplana* (P), *"Chonetes" lepidus* (P), *Devonochonetes scitulus* (P), *Mucrospirifer mucronatus* (C); Trilobita: *Phacops rana* (P). 11 to 12 feet below top (63 to 64 feet)—Brachiopoda: *Protoleptostrophia perplana* (P), *Schuchertella variabilis* (C), *Retichonetes aurora*? (P),

Unit		Unit Thickness	Cumulative Thickness
	"Chonetes" lepidus (C), *Cyrtina hamiltonensis* (C), *Mucrospirifer mucronatus* (A); Pelecypoda: *Nucula bellistriata* (P), *Palaeoneilo constricta* (P); Trilobita: *Phacops rana* (C). 15 to 16 feet below top (59 to 60 feet)—Brachiopoda: *Retichonetes aurora?* (P), *"Chonetes" lepidus* (A), *Longispina mucronatus* (A), *Cyrtina hamiltonensis* (C), *Mucrospirifer mucronatus* (C); Gastropoda: *Bucanopsis leda* (P); Trilobita: *Greenops boothi* (P), *Phacops rana* (P). In limestone 16 feet below top (59 feet)—Brachiopoda: *Devonochonetes scitulus* (VA); Pelecypoda: *Orthonota undulata* (P), *Nuculites oblongatus* (P); Gastropoda: bellerophontoid gastropod *Bembexia capillaria* (P); Cephalopoda: *Coleolus* sp. (P); Trilobita: *Trimerus (Dipleura) dekayi* (P). In limestone 17 feet below top (58 feet)—Brachiopoda: *Devonochonetes scitulus* (VA), *"Spirifer" tullius* (A), *Mucrospirifer mucronatus* (A); Pelecypoda: *Nuculites oblongatus* (P); Gastropoda: indet. gastropod sp. (P). In limestone 18 feet below top (57 feet)—Brachiopoda: *Devonochonetes scitulus* (VA), *Longispina mucronatus* (C), *Mucrospirifer mucronatus* (A); Pelecypoda: *Nuculites triqueter* (C), *Palaeoneilo constricta* (C); Gastropoda: indet. gastropod sp. (A).	38	75
2.	Interbedded siltstone and silty shale and claystone. Claystone, silty, medium-olive-gray (5Y4/2), weathering light olive gray. Six 8- to 24-inch beds of calcareous siltstone, medium-gray to medium-light-gray, weathering moderate to dark yellowish brown (10YR4/2) form 10 percent of subunit. Storm drain on north side of highway at 28 feet. Thickness 19 feet. Siltstone, weathered grayish red (5R4/2) to grayish purple (5RP4/2), in even beds commonly 4 inches thick. One-inch interbeds of silty shale form 30 per cent of subunit. Thickness 2 feet. Shale, silty, medium-greenish-gray, weathering medium brownish gray. One- to two-inch beds of calcareous siltstone, greenish-		

Unit		*Unit Thickness*	*Cumulative Thickness*
	gray, form 40 percent of subunit. Largely covered. Storm drain on north side of highway at 2 feet (stratigraphic) above base. Thickness 16 feet. Fossiliferous zones as noted: 2 to 5 feet below top (33 to 35 feet)—Brachiopoda: *Tropidoleptus carinatus* (C), *Delthyris sculptilis* (C), *"Spirifer" tullius* (P); Trilobita: *Trimerus (Dipleura) dekayi* (P). 11 feet below top (26 feet)—Brachiopoda: *Tropidoleptus carinatus* (C). 16 feet below top (21 feet)—Brachiopoda: *Tropidoleptus carinatus* (C), *"Spirifer" tullius* (P).	37	37

SUMMARY

Harrell Formation	3′
Tully Member	3′
Mahantango Formation	75′ exposed
Frame Member	75′ exposed

FOSSIL PLATES

EXPLANATION OF PLATE 4

Figure 1—*Conularia* sp. Lateral view of natural cast showing single lateral face with characteristic median longitudinal groove; x2. Upper part of Frame Shale Member at Huntingdon.

2, 3—*Pleurodictyum styloporum* (Eaton).

2. Lateral view of mold showing convex upper surface of corallum, four corallites with interconnecting mural pores, and vermicular tube extending to apical end of colony; x2. Upper part of Frame Shale Member at Huntingdon.

3. Ventral view of mold of corallum showing diaposition of corallites; x2. Upper part of Frame Shale Member at Huntingdon.

4-8—*Fenestella* cf. *F. emaciata* Hall.

4. External mold of back of zoarium having relatively large fenestrules; x2. Upper part of upper shale member at New Bloomfield.

5. External mold of back of zoarium; x2. Upper shale member at New Bloomfield.

6. External mold of back of zoarium showing subrhomboidal fenestrules and fine longitudinal striae; x5. Upper part of upper shale member at New Bloomfield.

7. External mold of front of zoarium, and molds of subrectangular to subrhomboidal zooecia; x5. Upper part of upper shale member at New Bloomfield.

8. External mold of front of zoarium, and molds of subrectangular zooecia; x5. Upper part of upper shale member at New Bloomfield.

9—*Fenestella* cf. *F. sinuosa* Hall. External mold of front of zoarium showing anastomose branches with 2 zooecial ranges separated by fine carinae; x5. Upper part of Frame Shale Member at Huntingdon.

10—*Polypora* cf. *P. celsipora* (Hall). External mold of front of zoarium showing anastomose branches with about 3 zooecial ranges separated by fine carinae; x5. Upper part of Frame Shale Member at Huntingdon.

11—*Polypora* sp. External mold of front of zoarium showing sub-parallel branches with zooaria more or less irregularly disposed; x5. Upper part of Frame Shale Member at Huntingdon.

12—*Unitrypa* sp. External mold of front of zoarium (in excavated areas) showing reticulate superstructure, and molds of zooecia; x3.3. Upper part of Frame Shale Member at Huntingdon.

EXPLANATION OF PLATE 5

Figure 1-3—*Sulcoretepora* cf. *S. incisurata* (Hall).

1. External mold of front of zoarium showing 7 zooecial ranges separated by fine longitudinal carinae, and flat branches; x7. Upper part of upper shale member at New Bloomfield.

2. Mesotheca showing arcuate transverse rugae; x2. Upper part of Frame Shale Member at Huntingdon.

3. External mold of front of zoarium, retaining molds of some zooecia, and with mesothecal wrinkles; x2. Upper part of upper shale member at New Bloomfield.

4—*Sulcoretepora* cf. *S. sinuosa* (Hall). External mold of front of zoarium showing irregular arrangement of zooecia and sinuosity of fine ridges between zooecia; x7. Upper part of upper shale member at New Bloomfield.

5, 6—*Sulcoretepora?* sp.

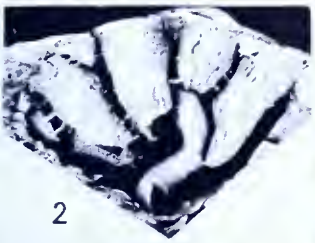
5. Internal mold of zoarium showing filling of axial hollow, with impressions of fine, longitudinal, mesothecal ridges, and showing portions of the hypostructure; x3. Upper part of Frame Shale Member at Huntington.

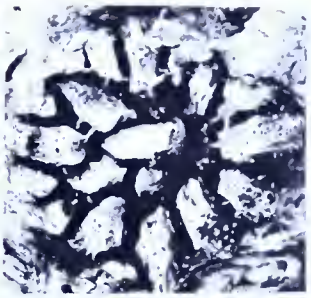
6. Internal mold of hypostructure showing irregularly polygonal chambers; x7. Upper part of Frame Shale Member at Huntington.

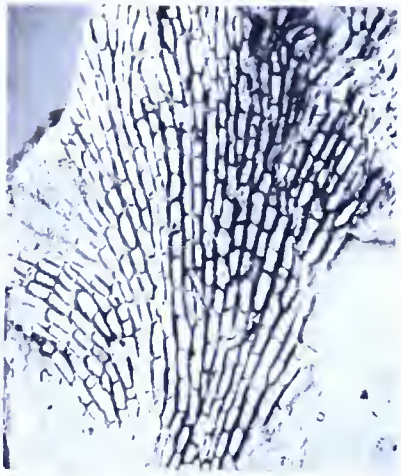
7—*Taeniopora exigua* Nicholson. External mold of front of zoarium showing pinnate branches and strong median carinae; x2. Upper part of Frame Shale Member at Huntingdon.

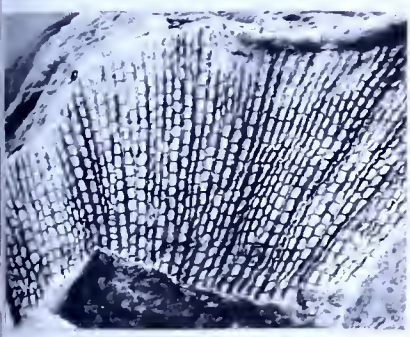
8—*Paleschara radiata* Hall. External mold of zoarium showing diamond-shaped apertures arranged in rosette pattern; x7. Gander Run Shale Member at Bedford.

1


2

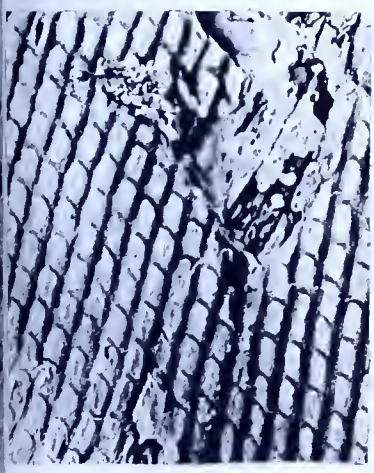

3

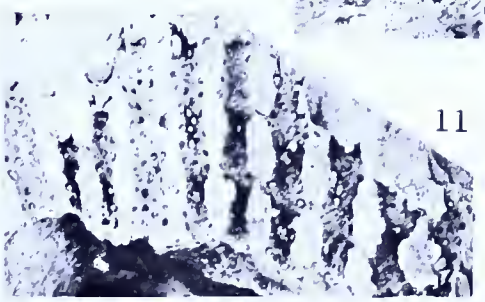

4


5

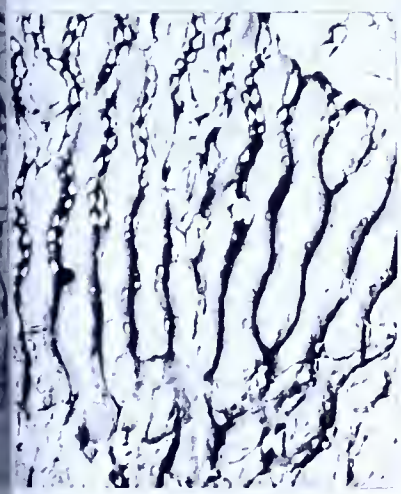
7

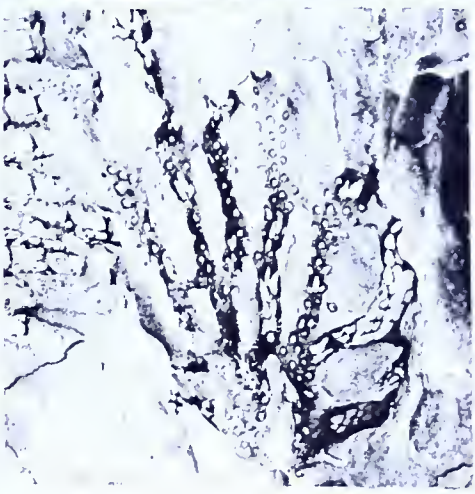
8

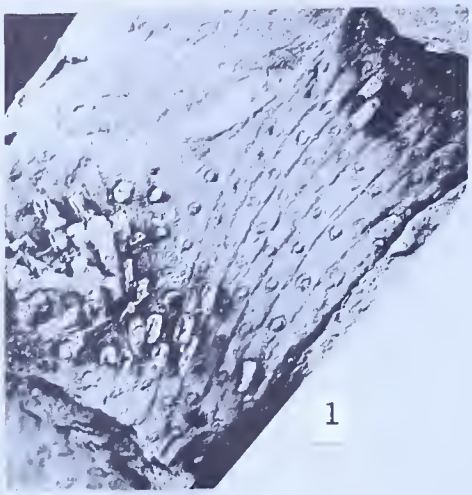

6


11

12


9

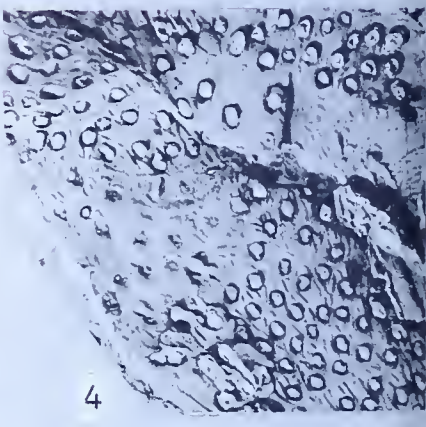

10



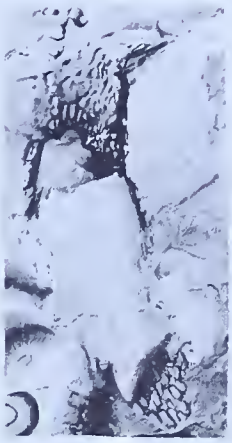
1

2

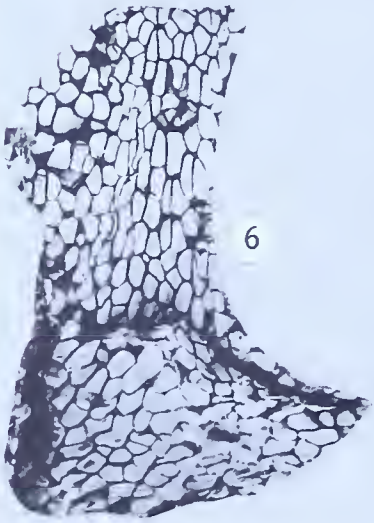
3



4

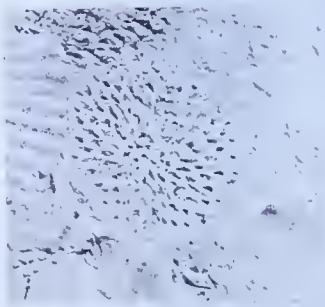


5



6

7



8

EXPLANATION OF PLATE 6

Figure 1, 2—*Lingula delia* Hall?

1. Nearly complete valve showing subquadrangular outline; x2. Upper part of Frame Shale Member at Newry.

2. Magnified portion of surface of valve in figure 1, showing wrinkled concentric striae; x10.

3—*Lingula ligea* Hall? Nearly complete brachial? valve showing elongate-ovate outline; x2. Upper shale member at New Bloomfield.

4—*Lingula?* sp. Complete valve showing broadly ovate outline, blunt posterior and lamellar structure of shell; x1. Lower shale member at Rockville.

5, 6—*Orbiculoidea doria* (Hall).

5. Large brachial valve with ovate outline, showing posterior position of apex, and faint concentric striae; x5. Upper part of Frame Shale Member at Bedford.

6. Brachial valve attached to shell of *Protoleptostrophia perplana*, showing circular outline, and posterior position of apex; x5. Upper part of Frame Shale Member at Bedford.

7—*Orbiculoidea tullia* (Hall)? Natural cast of brachial valve showing concentric striae, and apex situated about one-third of valve length forward of posterior margin; x3. Upper part of upper shale member at New Bloomfield.

8—*Schizobolus concentricus* (Vanuxem). Incomplete pedicle valve showing narrow foramen, notched posterior margin, and widely spaced, fine, concentric striae; x10. Upper part of Frame Shale Member at Newry.

9, 10—*Petrocrania hamiltoniae* (Hall).

9. Interior of brachial valve showing apical and marginal muscle scars, and *pi*-shaped scar at right end; x1. Upper part of upper shale member at Girtys Notch.

10. Interior of large brachial valve showing pair of marginal scars and pair of apical scars are somewhat darker, ovate features in figure; x1. Lower part of Frame Shale Member at Fishertown.

11, 12—*Craniops hamiltoniae* (Hall).

11. External mold of valve showing ovate outline and concentric lamellae; x10. Upper part of upper shale member at New Bloomfield.

12. Internal mold of pedicle valve showing apical muscle scar transected by Y-shaped structure; x10. Upper part of Frame Shale Member at Huntingdon.

13, 14—*Rhipdomella leucosia* (Hall).

13. Internal mold of brachial valve showing broadly ovate outline, cordate muscle scars, and cardinalia, consisting of socket plates, brachiophores, and cardinal process; x1. Middle part of upper shale member at New Bloomfield.

14. Internal mold of brachial valve showing broadly ovate outline, cordate muscle scars, and cardinalia; x1. Middle part of upper shale member at New Bloomfield.

15-18—*Rhipidomella penelope* (Hall).

15, 16. Internal molds of pedicle valves showing subcircular outline, large, flabellate muscle scars, and open delthyrium bounded by teeth; x1. Montebello Sandstone Member at Falling Springs.

17. Interior of Plastiflex cast of specimen in figure 16, showing nature of delthyrium and teeth; xI.

18. External mold of pedicle valve in coarse-grained sandstone, showing fine radial striae; x1. Montebello Sandstone Member at Falling Springs.

19-25—*Rhipidomella vanuxemi* (Hall).

19, 20. External molds of 2 small, somewhat atypical pedicle valves showing radial ornament that is posteriorly deflected; note impressions of pits along ribs of specimen in Figure 19; x3. Upper part of Frame Shale Member at Bedford.

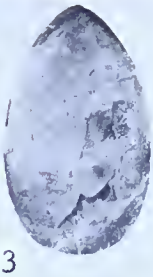
21. Pedicle valve with fine ornament; x1. Upper part of Chaneysville Siltstone Member at Fishertown.

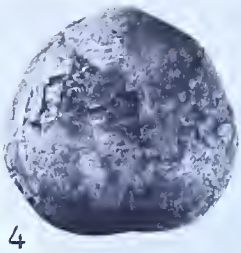
22. Internal mold of pedicle valve showing somewhat larger than average muscle scars; x1. Upper part of Chaneysville Siltstone Member at Fishertown.

23. Internal mold of brachial valve showing impressions of cardinal process, divergent brachiophores, and median septa; x1. Upper part of Chaneysville Siltstone Member at Fishertown.

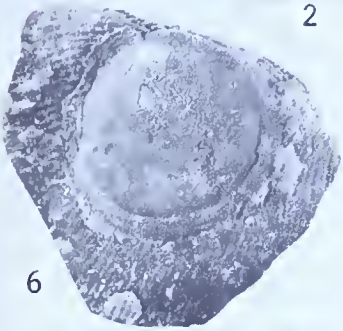
1

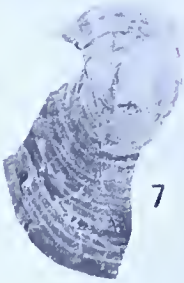
2

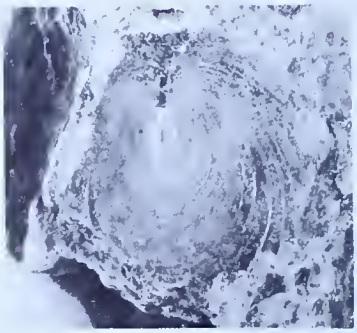

3

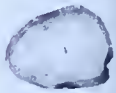

4

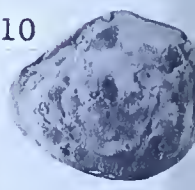
5

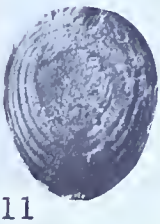

6

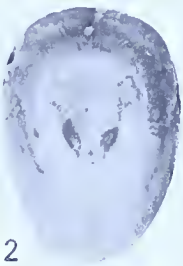

7

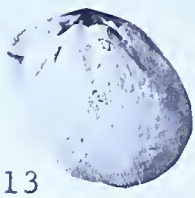

8

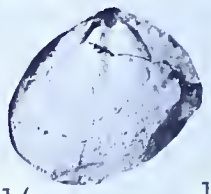

9


10

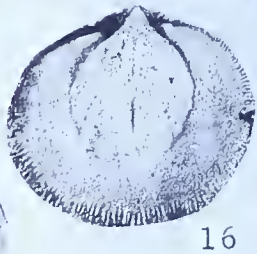

11


12

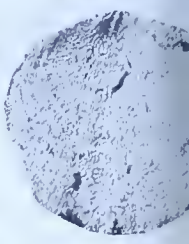

13

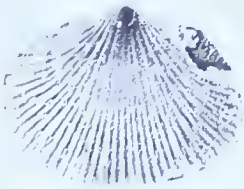

14

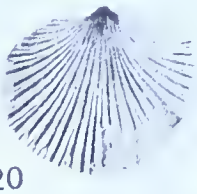
15

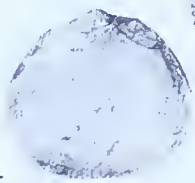

16

17

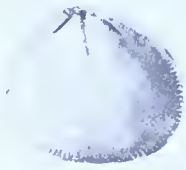

18

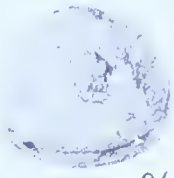

19


20

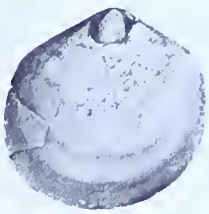

21

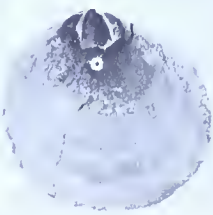
22


23


24

25

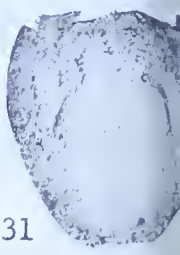

26


27

28

29

30


31

EXPLANATION OF PLATE 6—Continued

24. Brachial valve with fine ornament; x1. Upper part of Chaneysville Siltstone Member at Fishertown.

25. Interior of brachial valve showing prominent cardinal process, extended brachiophores, and small interarea with short hinge; x1. Upper part of Chaneysville Siltstone Member at Fishertown.

26, 27—*Centronella?* sp.

26. Cast of pedicle valve with pedicle portion of cast removed, showing internal mold of that part of valve; x2. Upper part of upper shale member at New Bloomfield.

27. External mold of specimen in figure 26, with a piece of cast showing pedicle opening at apex of valve; x2.

28-31—*Subrensselandia claypolii* (Hall).

28. Internal mold of brachial valve showing impressions of broad crural plates and muscle scars; x1. Lower part of Montebello Sandstone Member at Dromgold.

29. Internal mold of pedicle valve showing impressions of divergent teeth and open foramen; x1. Lower part of Montebello Sandstone Member at Dromgold.

30. Plastiflex cast of brachial valve in figure 31, showing hinge plates; x1.

31. Internal mold of brachial valve showing impressions of broad hinge plates and muscle scars; x1. Lower part of Montebello Sandstone Member at Dromgold.

EXPLANATION OF PLATE 7

Figure 1-15—*Tropidoleptus carinatus* (Conrad).

1-4. Internal molds of pedicle valves showing variation in size and form; x1. Upper part of Montebello Sandstone Member at Rockville.

5. Internal mold of pedicle valve; x1. Upper part of upper shale member at Girtys Notch.

6. Pedicle valve with fragments of shell material; x1. Frame Shale Member at Websters Mill.

7. External mold of slightly deformed pedicle valve; x1. Upper part of upper shale member at New Bloomfield.

8. Internal mold of brachial valve showing impressions of crenulate dental sockets; x1. Upper part of upper shale member at New Bloomfield.

9. External mold of brachial valve; x1. Frame Shale Member at Everett turnpike.

10. External mold of brachial valve; x1. Lower part of Montebello Sandstone Member at Amity Hall.

11. External mold of brachial valve; x1. Chaneysville Siltstone Member at Everett turnpike

12. External mold of brachial valve; x1. Montebello Sandstone Member at Girtys Notch.

13. Internal mold of large brachial valve showing impression of median septum and impression of crenulate dental sockets; x1. Upper shale member at Mahantango Creek.

14. Typical assemblage of specimens from upper shale member at Mahantango Creek; x1.

15. Magnified portion of internal mold showing impressions of crenulate dental sockets and cardinal process of brachial valve; x3. Lower part of Frame Shale Member at Fishertown.

16, 17—*Leiorhynchus limitare* (Vanuxem).

16. Internal mold of slightly deformed pedicle valve; x1. Gander Run Shale Member at Bedford.

17. Internal mold of brachial valve showing well defined median septum; x1. Gander Run Shale Member at Bedford.

18-20—*Leiorhynchus mesacostale* Hall

18. Internal mold of slightly deformed pedicle valve showing 3 or 4 plicae in sulcus, and near obsolescence of plicae on lateral slopes; x1. Tully Member of Harrell Formation at New Bloomfield.

EXPLANATION OF PLATE 7—Continued

19. Internal mold of slightly deformed pedicle valve showing 3 or 4 plicae in sulcus, and near obsolescence of plicae on lateral slopes; x1. Tully Member of the Harrell Formation at New Bloomfield.

20. Internal mold of brachial valve showing prominent median septum, and fold with few faint plicae; x1. Tully Member of Harrell Formation at New Bloomfield.

21—*Leiorhynchus multicostum* Hall. Internal mold of brachial valve showing faint plicae on lateral slopes as well as on fold; x1. Crooked Creek Shale Member at Huntingdon.

22-28—*Camarotoechia congregata* (Conrad).

22. Internal mold of pedicle valve showing impressions of short dental lamellae and relatively coarse plicae; x2. Upper part of Montebello Sandstone Member at Rockville.

23. Pedicle valve showing 3 plicae in sulcus; x2. Upper part of Montebello Sandstone Member at Rockville.

24. Pedicle valve showing 3 plicae in sulcus; x2. Upper part of Montebello Sandstone Member at Rockville.

25. Internal mold of pedicle valve; x2. Upper part of Montebello Sandstone Member at Rockville.

26. External mold of deformed pedicle valve; x2. Gander Run Shale Member at Martins Gap.

27. Lateral view of internal mold of both valves showing plicae deflected toward commissure; x2. Chaneysville Siltstone Member at Chaneysville.

28. Brachial view of internal mold displaying strong median septum, and 4 plicae on fold; x2. Upper part of Montebello Sandstone Member at Falling Springs.

29, 30—*Camarotoechia prolifica* Hall.

29. Internal mold of pedicle valve displaying subcircular outline and relatively fine radial plicae; x2. Upper part of Montebello Sandstone Member at Rockville.

30. Internal mold of brachial valve showing median septum and fine plicae; x2. Upper part of Montebello Sandstone Member at Rockville.

31-33—*Camarotoechia sappho* Hall.

31. Pedical valve showing plicae posteriorly deflected near lateral margins. and relatively transverse form; x2. Montebello Sandstone Member at Rockville.

32. Brachial view of internal mold revealing median septum and deflected plicae; x2. Lower part of upper shale member at Girtys Notch.

33. Pedicle valve showing outline, and bearing 4 plicae in sulcus; x2. Montebello Sandstone Member at Rockville.

34-37—*Hypothyridina venustula* (Hall).

34. Anterior view of specimen showing strong, rectangular sulcus and uniform radial ornament; x1. Tully Member of the Harrell Formation at Newry.

35. Brachial valve of slightly deformed specimen; x1. Tully Member of Harrell Formation at Newry.

36. Pedicle view of specimen in figure 34, showing outline of shell, and nature of radial ornament; x1.

EXPLANATION OF PLATE 8

Figure 1-4—*Schuchertella variabilis* Prosser and Kindle.

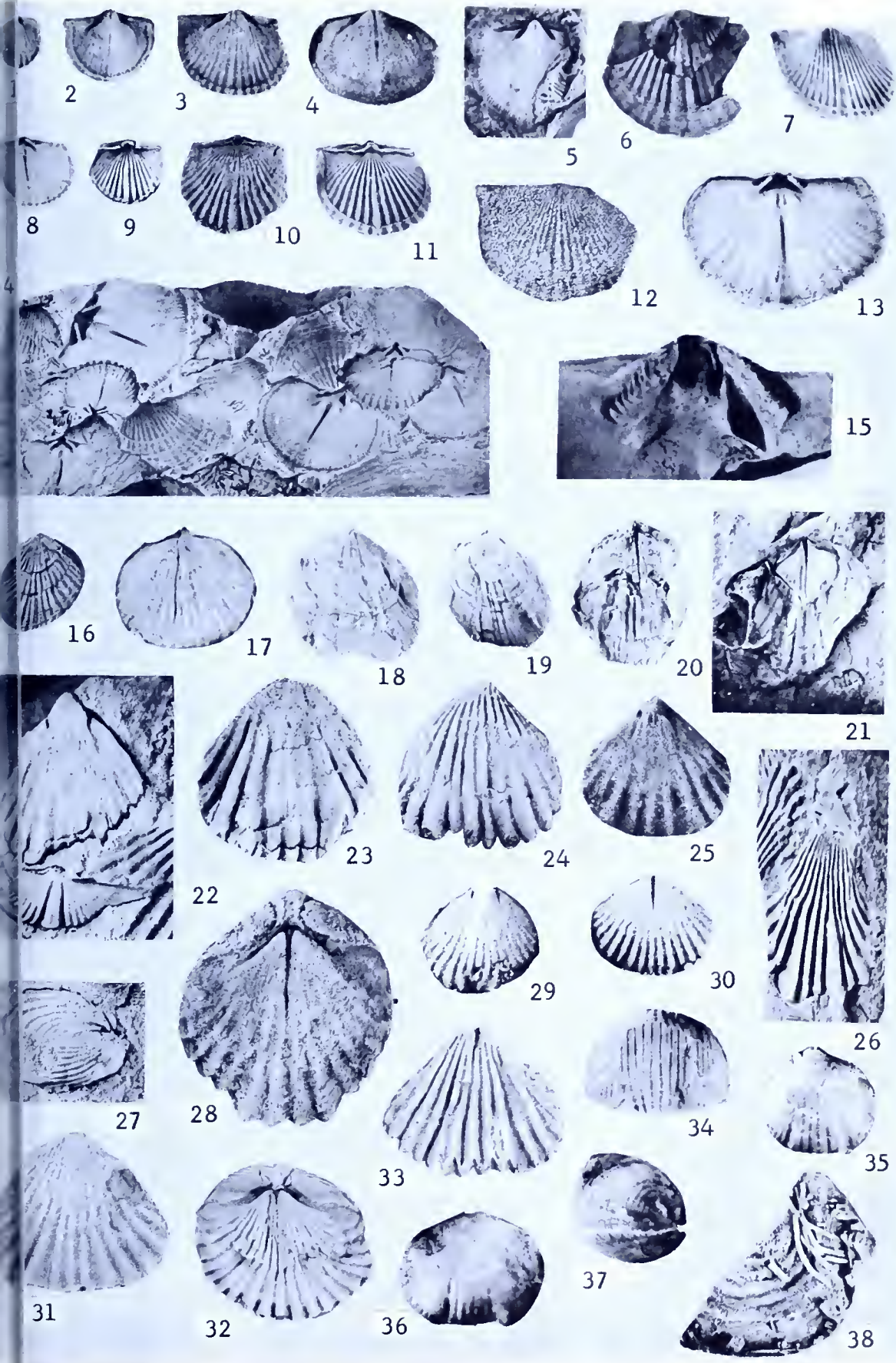
1. Internal mold of slightly distorted pedicle valve revealing parvicostellate ornament; x2. Upper part of upper shale member at Girtys Notch.

2. Internal mold of elongate pedicle valve showing parvicostellate ornament; x2. Upper part of Chaneysville Siltstone Member at Fishertown.

3. External mold of brachial valve showing parvicostellate ornament; x2. From an exposure near East Freedom, in Blair County.

4. External mold of brachial valve showing parvicostellate ornament; x2. Upper part of Frame Shale Member at Barnetts Mill.

5—*Stropheodonta demissa* (Conrad). External mold of pedicle valve showing parvicostellate ornament; x1. Upper part of upper shale member at New Bloomfield.


2
3
4
5
6
7
8
9
10
11
12
13
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38

EXPLANATION OF PLATE 8—Continued

6—*Megastrophia concava* (Hall). External mold of concave brachial valve showing parvicostellate ornament consisting of numerous secondary costellae between each primary; x1. Upper part of upper shale member at Girtys Notch.

7-15—*Protoleptostrophia perplana* (Conrad).

7. Internal mold of pedicle valve showing impressions of muscle-bounding ridges and median septum; x1. Upper part of Frame Shale Member at Bedford.

8. Internal mold of brachial valve showing impressions of braceplates and disjunct cardinal process, as well as pseudopunctate surface; x1. Upper part of Chaneysville Siltstone Member at Fishertown.

9. Internal mold of medium-sized pedicle valve; x1. Upper part of Frame Shale Member at Bedford,

10. External mold of pedicle valve shown in figure 9; x1.

11. Internal mold of elongate pedicle valve; x1. Upper part of Frame Shale Member at Huntingdon.

12. Internal mold and some associated shell material of unusually large pedicle valve showing impressions of divergent muscle-bounding ridges and pseudopunctate interior; x1. Upper part of Frame Shale Member at Huntingdon.

13. Enlarged portion of external mold of brachial valve displaying cicatrix toward which medial striae converge; x3. Upper part of upper shale member at New Bloomfield.

14. External mold of brachial valve bearing median cicatrix, and showing fine concentric and radial ornament; x1. Upper part of Frame Shale Member at Huntingdon.

15. Internal mold of pedicle valve preserving some shell material in area of beak, showing denticulate hinge line; x1. Upper part of Chaneysville Siltstone Member at Fishertown.

16, 17—*Pholidostrophia pennsylvanica* Kindle.

16. Pedicle valve displaying nacreous luster; x2. Upper part of Montebello Sandstone Member at Rockville.

17. Internal mold of pedicle valve; x2. Upper part of upper shale member at Girtys Notch.

18-21—*Douvillina inacquistriata* (Conrad).

18. Internal mold of elongate pedicle valve showing distinctive muscle, scars; x1. Upper part of upper shale member at New Bloomfield.

19. Internal mold of transverse pedicle valve showing muscle areas, denticulate hinge line, and pseudopunctate interior; x1. Upper part of Crooked Creek Shale Member at Martins Gap.

20. External mold of pedicle valve showing alternating coarse and fine costellae; x1. Upper part of upper shale member at New Bloomfield.

21. External mold of brachial valve showing alternating coarse and fine costellae; x1. Upper part of Crooked Creek Shale Member at Martins Gap.

22-27—*Douvillina inaequistriata* var. *immatura,* n. var.

22. External mold of pedicle valve displaying parvicostellate ornament with several fine striae between primary costellae; x2. Upper part of upper shale member at Girtys Notch.

23. Internal mold of pedicle valve showing impressions of 2 pair of muscle bounding ridges; x2. Upper part of upper shale member at Girtys Notch.

24. Internal mold of brachial valve showing impressions of strong braceplates bounded laterally by furrow and elevation; x1. Upper part of upper shale member at Girtys Notch.

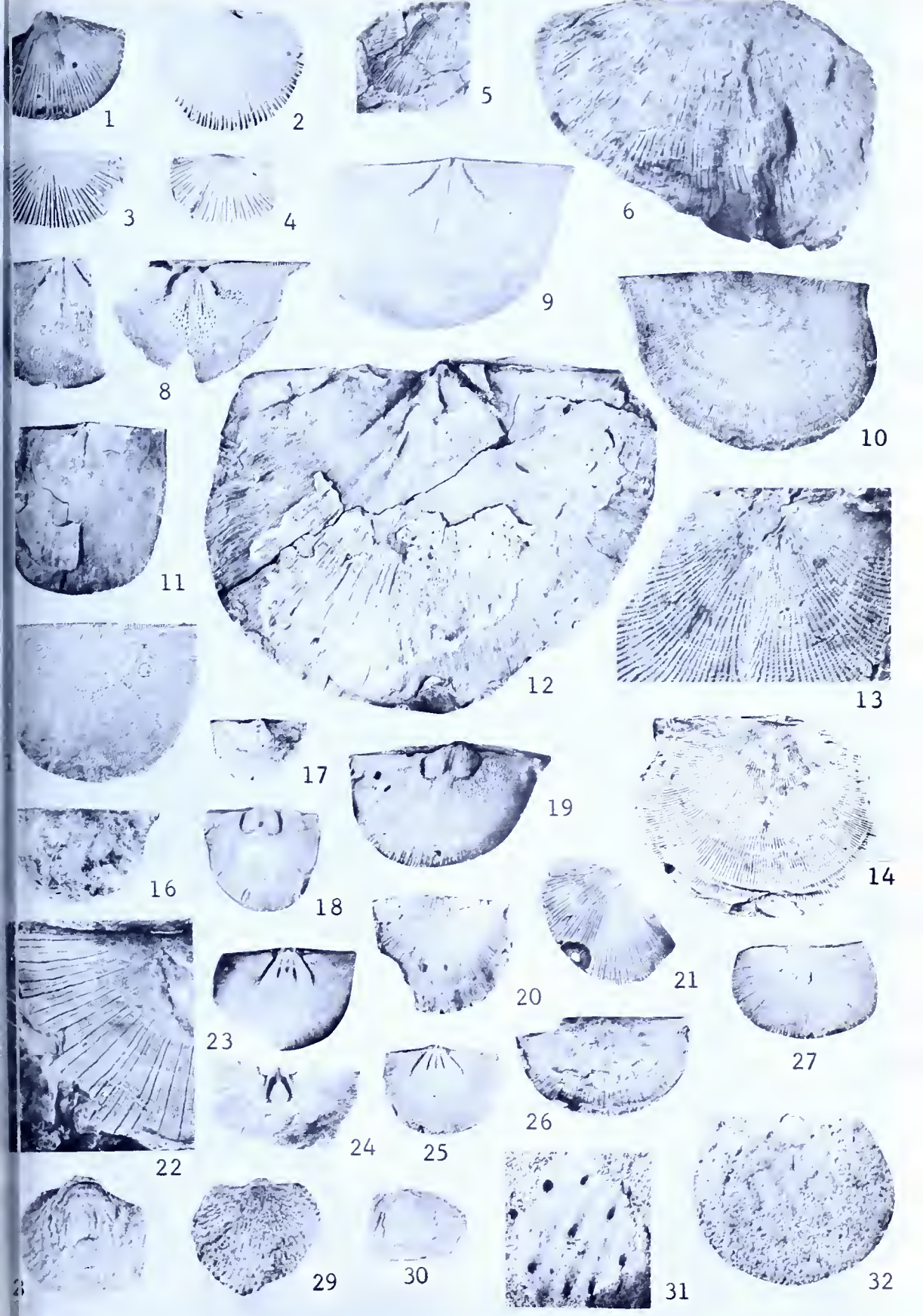
25. Internal mold of pedicle valve showing impressions of muscle-bounding ridges, denticulate hinge line, and pseudopunctate interior; x2. Upper part of upper shale member at Girtys Notch.

26. External mold of concave brachial valve with shell material showing parvicostellate ornament; x1. Upper part of upper shale member at Girtys Notch.

27. External mold of nearly flat brachial valve showing primary costellae; x2. Upper part of upper shale member at Girtys Notch.

28-31—*Productella spinulicosta* (Hall).

28. Natural cast of pedicle valve showing spinose exterior; x1. Upper part of Montebello Sandstone Member at Rockville.


1
2
3
4
5
6
8
9
10
11
12
13
14
16
17
18
19
20
21
22
23
24
25
26
27
29
30
31
32

EXPLANATION OF PLATE 8—Continued

29. Pedicle valve bearing finer and more numerous spines than specimen in figure 28; x1. Upper part of Montebello Sandstone Member at Rockville.

30. Natural cast of transverse pedicle valve displaying spines; x1. Upper part of upper shale member at Girtys Notch.

31. External mold of shell fragment showing impressions of spines; x5. Middle part of upper shale member at New Bloomfield.

32—*Truncalosia truncata* (Hall). External mold of brachial valve showing posteriorly truncate outline of shell, and impression of nodose exterior; x7. Gander Run Shale Member at Bedford.

EXPLANATION OF PLATE 9

Figure 1—*Retichonetes? aurora* Hall. Pedicle valve showing reticulate ornament; x7. Tully Member of Harrell Formation at Newry.

2-9—*Devonchonetes coronatus* (Conrad).

2. External mold of brachial valve showing impressions of radial ornament consisting of intercalated costellae; x2. Lower part of upper shale member at New Broomfield.

3. External mold of brachial valve showing nature of ornament; x2. Upper part of Montebello Sandstone Member at Rockville.

4. External mold of brachial valve showing nature of ornament; x2. Upper part of upper shale member at Girtys Notch.

5. Plastiflex cast of brachial interior displaying muscle areas, prominent median septum, and quadrilobate cardinal process; x1. Upper part of Montebello Sandstone Member at Amity Hall.

6. Plastiflex cast of brachial interior displaying cardinal process, median septum, and ridges bounding muscle areas posteriorly; x1. Upper part of Montebello Sandstone Member at Amity Hall.

7. Internal mold of pedicle valve showing impression of median septum, and pseudopunctate interior; x1. Upper part of Frame Shale Member at Bedford.

8. Internal mold of plastic valve showing impression of median septum, and pseudopunctate interior; x1. Lower part of Montebello Sandstone Member at Millerstown.

9. External mold of fragmentary specimen of pedicle valve displaying fine radial ornament; x1. Montebello Sandstone Member at Girtys Notch.

10—*"Chonetes" lepidus* (Hall). Internal mold of pedicle valve showing suberect cardinal spines, and 2 prominent plicae on either side of slight sulcus; x16. Frame Shale Member at Huntingdon.

11, 12—*Retichonetes marylandicus* Prosser and Kindle.

11. Internal mold with some shell material of pedicle valve showing fine radial ornament; x2. Chaneysville Siltstone Member at Everett turnpike.

12. External mold of brachial valve displaying finer radial ornament; x2. Chaneysville Siltstone Member at Everett turnpike.

13-34—*Devonochonetes scitulus* (Hall).

13. External mold of pedicle valve showing radial ornament, and impressions of 2 cardinal spines; x2. Lower part of upper shale member at New Bloomfield.

14. External mold of brachial valve associated with pedicle valve in figure 13, showing ornament and interarea, as well as cardinal spines; x2. Lower part of upper shale member at New Bloomfield.

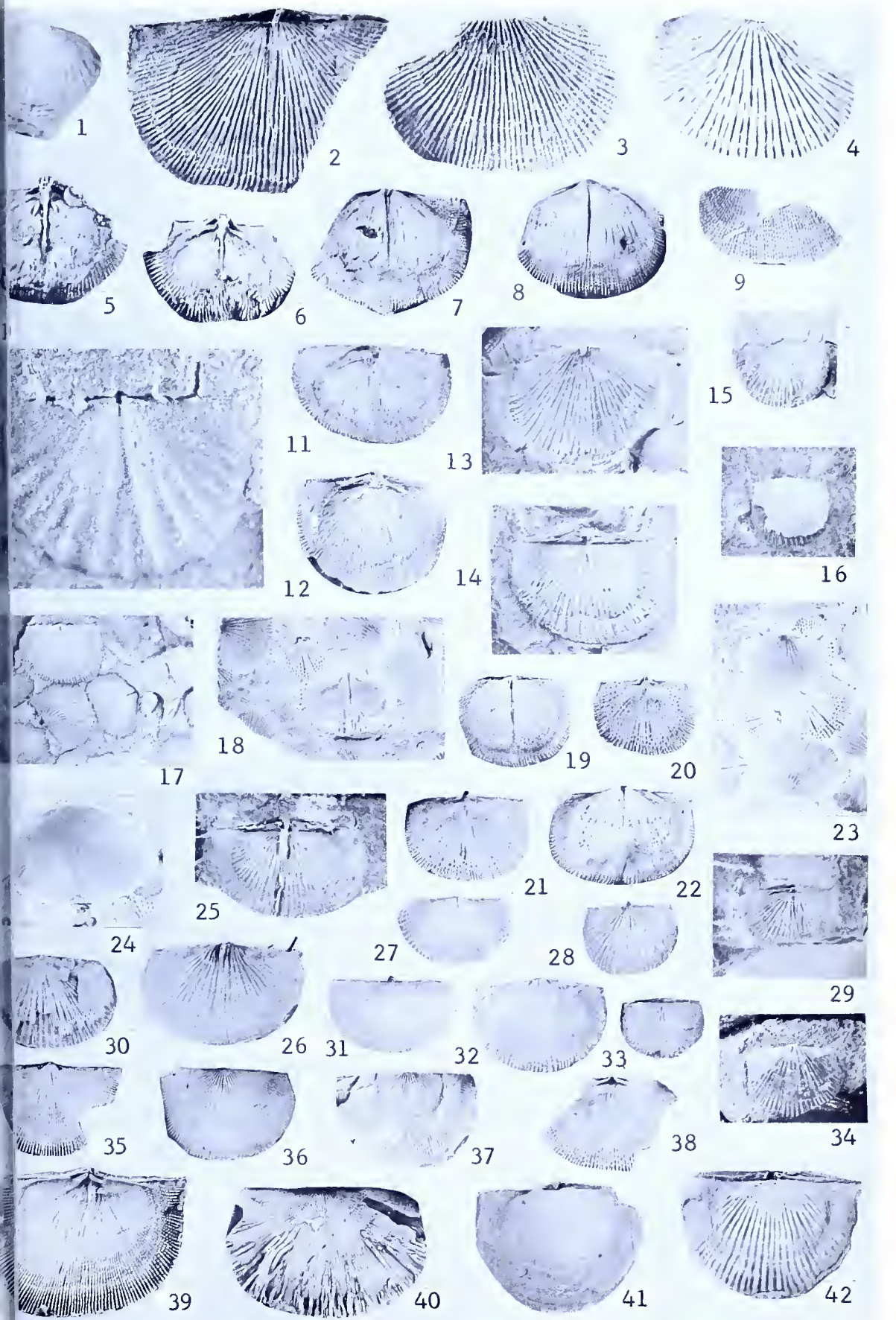
15. Natural cast of elongate pedicle valve with suberect carlinal spines; x2. Upper part of Frame Shale Member at Newry.

16. Pedicle valve showing radial ornament and 3 cardinal spines on left side of beak; x2. Upper part of Frame Shale Member at Huntingdon.

17, 18, 23. Groups of internal and external molds of specimens displaying external ornament, and features such as muscle areas, median septa, and pseudopunctae; x2. Chaneysville Siltstone Member at Websters Mill.

19. Internal mold of pedicle valve showing impression of median septum, large flabellate muscle areas, and pseudopunctae; x2. Chaneysville Siltstone Member at Websters Mill.

20. Internal mold of brachial valve revealing impressions of dental sockets, and pseudopunctae; x2. Chaneysville Siltstone Member at Websters Mill.


1
2
3
4
5
6
7
8
9
11
13
15
12
14
16
17
18
19
20
23
24
25
21
22
27
28
29
30
26
31
32
33
34
35
36
37
38
39
40
41
42

EXPLANATION OF PLATE 9—Continued

21. Internal mold of brachial valve with little development of pseudopunctae; x2. Chaneysville Siltstone Member at Websters Mill.

22. Internal mold of large pedicle valve; x2. Chaneysville Siltstone Member at Websters Mill.

24. External mold of specimen in figure 22, showing fine, intercalated radial ornament; x2.

25. External mold of brachial valve showing general outline, radial ornament, and at least 1 cardinal spine on either side of beak; x2. Upper part of Frame Shale Member at Huntingdon.

26. External mold of pedicle valve of specimen in figure 25; x2.

27. Internal mold of small, convex pedicle valve; x2. Upper part of Frame Shale Member at Newry.

28. External mold of elongate brachial valve; x2. Upper part of Frame shale at Newry.

29. External mold of transverse brachial valve; x2. Upper part of Frame Shale Member at Huntingdon.

30. External mold with some shell material of brachial valve revealing internal pseudopunctae; x2. Upper part of Frame Shale Member at Huntingdon.

31. External mold of brachial valve showing radial ornament that is faint on cardinal margins; x2. Upper part of Frame Shale Member at Huntingdon.

32. Internal mold of very convex pedicle valve; x2. Upper part of Frame Shale Member at Huntingdon.

33. External mold of brachial valve showing somewhat flattened cardinal angles lacking ornament; x2. Upper part of Frame Shale Member at Huntingdon.

34. Internal mold of pedicle valve with some shell material, showing nature of ornament, and obliquely directed cardinal spines; x2. Upper part of Frame Shale Member at Huntingdon.

35-40—*Devonochonetes syrtalis* (Conrad).

35. Internal mold of pedicle valve with extended hinge, showing impressions of cardinal teeth, pseudopunctae, and internal reflection of external ornament; x1. Upper part of Montebello Sandstone Member at Falling Springs.

36. External mold of nearly flat brachial valve showing nature of external ornament; x1. Lower part of Chaneysville Siltstone Member at Websters Mills.

37. External mold of concave brachial valve showing nature of external ornament; x1. Chaneysville Siltstone Member at Chaneysville.

38. Internal mold of brachial valve showing impressions of dental sockets, fine median septum, and pseudopunctae arranged along radial furrows; x1. Chaneysville Siltstone Member at Websters Mill.

39. Plastiflex cast of pedicle interior showing cardinal teeth and fine radial ornament; x1. Upper part of Montebello Sandstone Member at Amity Hall.

40. External mold of nearly flat brachial valve perforated by worm or sponge borings; x1. Chaneysville Siltstone Member at Websters Mill.

41, 42—*Retichonetes vicinus* (Castelnau)

41. External mold of brachial valve showing extreme concavity, and coarse radial ornament; x2. Lower part of upper shale member at New Bloomfield.

42. External mold of brachial valve showing extreme concavity, and coarse radial ornament; x2. Lower part of Frame Shale Member at Fishertown.

EXPLANATION OF PLATE 10

Figure 1-8—*Longispina mucronatus* (Hall).

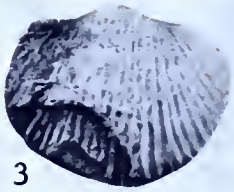
1. Internal mold of pedicle valves showing median septa and internal reflection of external ornament; x2. Chaneysville Siltstone Member at Websters Mill.

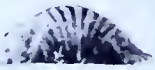
2. External molds of specimens in figure 1, showing coarse radial ornament that appears to radiate from point beyond beak; x2.

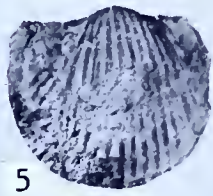
3. Pedicle valve showing nature of ornament; x2. Upper part of Chaneysville Siltstone Member at Fishertown.

4. Posterior view of specimen in figure 3; x2.

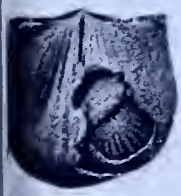
1

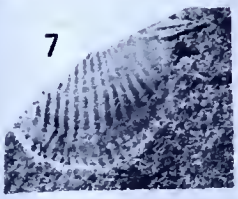

3

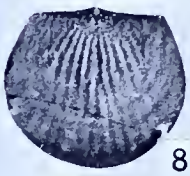

4

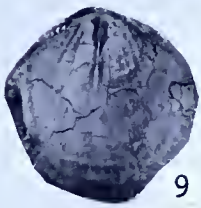

5

2

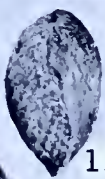

6

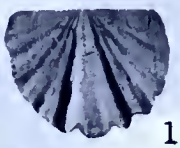

7

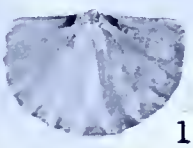

8

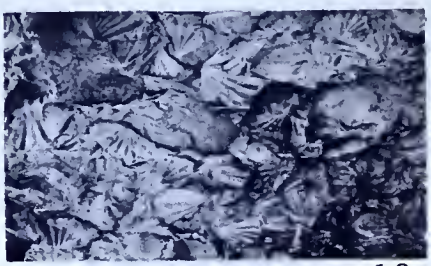

9

10

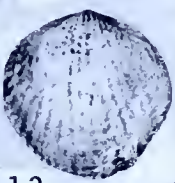

12


14

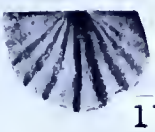

15

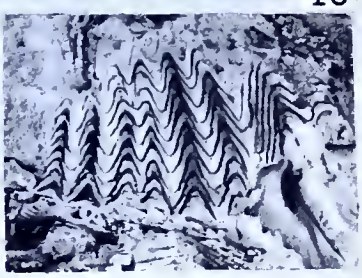

18

11

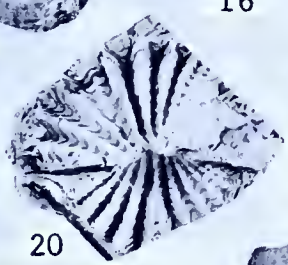

13

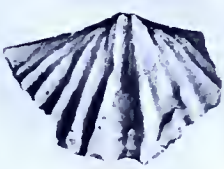
16

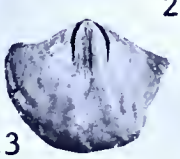

17


22

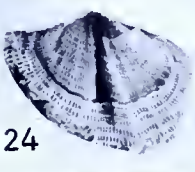
19

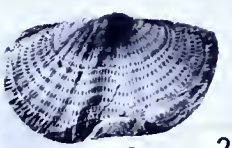

20

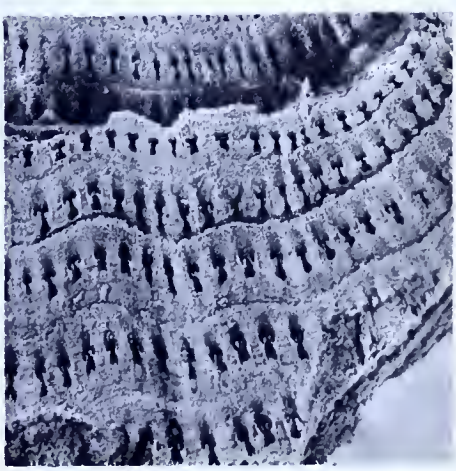

21


23

26


24


25


27

EXPLANATION OF PLATE 10—Continued

5. Pedicle valve showing nature of ornament; x2. Upper part of Chaneysville Siltstone Member at Fishertown.

6. Internal mold of pedicle valve showing median septum; lower portion broken away, revealing more impressions; x2. Chaneysville Siltstone Member at Websters Mill.

7. External mold of pedicle valve showing impressions of spines directed nearly parallel to hinge; x2. Backbone Ridge Siltstone Member at Huntingdon.

8. External mold of brachial valve showing nature of ornament; x2. Chaneysville Siltstone Member at Websters Mill.

9. 10—*Atrypa reticularis* (Linnaeus).

9. Internal mold of pedicle valve showing median septum and muscle areas; x1. Upper part of Frame Shale Member at Elk Lick Creek.

10. External mold of pedicle valve showing reticulate ornament; x1. Upper part of upper shale member at Amity Hall.

11-13—*Atrypa spinosa* Hall.

11. External mold of fragment of specimen showing radial costae and concentric lamellae; x1. Upper part of upper shale member at Amity Hall.

12. Lateral view of shell showing relative convexity of 2 valves; x1. Tully Member of Harrell Formation at Bedford.

13. Pedicle view of specimen shown in figure 12, displaying reticulate ornament; exfoliation has removed spines.

14-18—*Pustulatia pustulosa* (Hall).

14. External mold of brachial valve revealing few, coarse plicae, two of which are prominent and bound the median sulcus; x2. Upper part of upper shale member at New Bloomfield.

15. Internal mold of pedicle valve showing impressions of cardinal teeth and faint radial ornament; x2. Upper part of upper shale member at New Bloomfield.

16. Internal mold of brachial valve displaying impressions of dental sockets; x2. Upper part of upper shale member at New Bloomfield.

17. External mold of pedicle valve showing few radial plicae and strong median fold; x2. Upper part of upper shale member at New Bloomfield.

18. Group of shells illustrating common mode of occurrence; x1. Upper part of upper shale member in an exposure near Eschol, in Perry Co.

19-22—*Delthyris sculptilis* Hall.

19. External mold of pedicle valve showing strong radial plicae and angular concentric lamellae; x1. Upper part of Frame Shale Member at Bedford.

20. External molds of brachial and pedicle valves showing nature of external ornament; x1. Upper part of Frame Shale Member at Bedford.

21. Internal mold of pedicle valve shown in figure 19; x1.

22. External mold of fragment of specimen with very closely spaced concentric lamellae; x3. Upper part of upper shale member at Girtys Notch.

23-27—*Elytha fimbriata* (Conrad).

23. Internal mold of pedicle valve displaying impressions of dental plates; x1. Upper part of upper shale member at Amity Hall.

24. External mold of brachial valve showing median sulcus, concentric lamellae, and bases of double-barrelled spines; x1. Donation Siltstone Member at Huntingdon.

25. External mold of brachial valve showing median sulcus, radial plicae, concentric lamellae, and bases of spines; x1. Upper part of upper shale member at Amity Hall.

26. Internal and external mold of margin of brachial valve revealing impressions of slender, double-barrelled spines; x3. Donation Siltstone Member at Huntingdon.

27. External mold of shell showing impressions of bases of spines; x3. Donation Siltstone Member at Huntingdon.

EXPLANATION OF PLATE 11

Figure 1, 2—*Emmanuella subumbona* (Hall)?

1. Internal mold of pedicle valve showing impressions of muscle areas; valve somewhat distorted; x2. Tully Member of Harrell Formation at New Bloomfield.

2. External mold of pedicle valve showing general outline, fine concentric striae, and absence of sulcus; x2. Tully Member of Harrell Formation at New Bloomfield.

3-6—*Emmanuella pennsylvanica* Willard.

3. Brachial view of specimen showing smooth surface and general shell outline; x1. Tully Member of Harrell Formation at Newry.

4. Pedicle valve showing smooth exterior; x1. Tully Member of Harrell Formation at Newry.

5. Lateral view of shell showing relative convexity of valves, and extension of pedicle beak; x1. Tully Member of Harrell Formation at Newry.

6. Pedicle valve of specimen somewhat more elongate than specimen in figure 4; x1. Tully Member of Harrell Formation at Newry.

7—*Paraspirifer acuminatus* (Conrad). Fragment of internal mold of brachial valve with suggestion of faint, bifurcating plicae, and high, carinate fold; x1. Lower part of Montebello Sandstone Member at Millerstown.

8-14—*Spinocyrtia granulosa* (Conrad).

8. Pedicle valve displaying broad, shallow sulcus, coarse radial ornament, and fine concentric ornament; x1. Chaneysville Siltstone Member at Fishertown.

9. Internal mold of pedicle valve showing impressions of delthyrial cavity, striated muscle areas, and prominent dental lamellae; x1. Donation Siltstone Member at Huntingdon.

10. Internal mold of pedicle valve showing general outline of valve, impressions of muscle areas, and dental lamellae; x1. Donation Siltstone Member at Huntingdon.

11. Brachial valve showing general outline of valve and nature of surface ornament; x1. Chaneysville Siltstone Member at Fishertown.

12. Plastiflex cast of brachial valve; lateral view showing profile of valve and relative prominence of brachial fold; x1. Upper part of upper shale member at New Bloomfield.

13. Brachial view of specimen shown in figure 12, revealing strong brachial fold and coarse radial ornament; x1.

14. External mold of valve showing impressions of elongate granules; x3. Donation Siltstone Member at Huntingdon.

15-17—*Spinocyrtia granulosa clintoni* (Hall).

15. Plastiflex cast of pedicle valve showing deep, angular sulcus and coarse radial ornament; x1. Chaneysville Siltstone Member at Chaneysville.

16. Internal mold of pedicle valve displaying impressions of angular sulcus, striate muscle areas, delthyrial cavity, and strong dental lamellae; x1. Chaneysville Siltstone Member at Chaneysville.

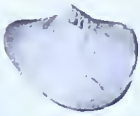
17. External mold of valve showing striato-granulose ornament; x3. Chaneysville Siltstone Member at Everett turnpike.

18-20—*Spinocyrtia granulosa girtyi* Ellison n. subsp.

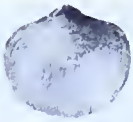
18. Internal mold of pedicle valve showing impressions of muscle areas, strong dental lamellae, and delthyrial cavity; x1. Montebello Sandstone Member at Girtys Notch.

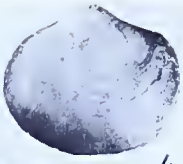
19. Internal mold of brachial valve showing strong median septum; x1. Montebello Sandstone Member at Amity Hall.

20. External mold of pedicle valve showing subangular sulcus; x1. Montebello Sandstone Member at Girtys Notch.


1

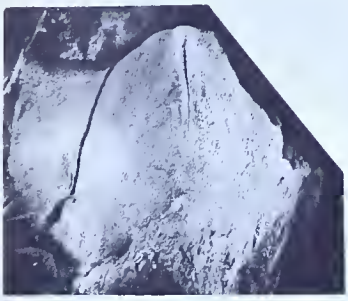
2

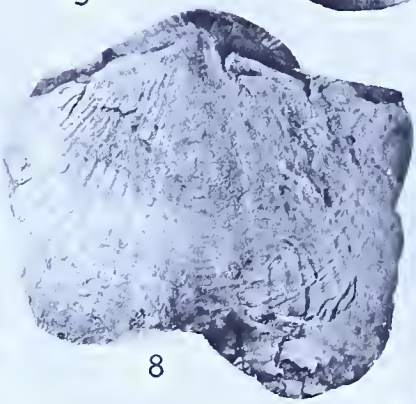

3

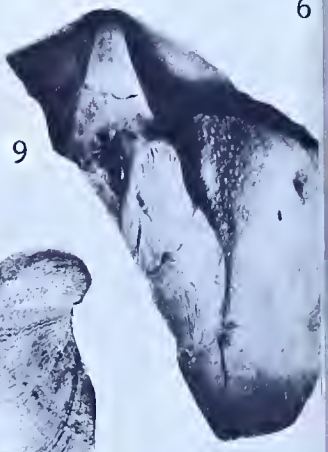

4

5

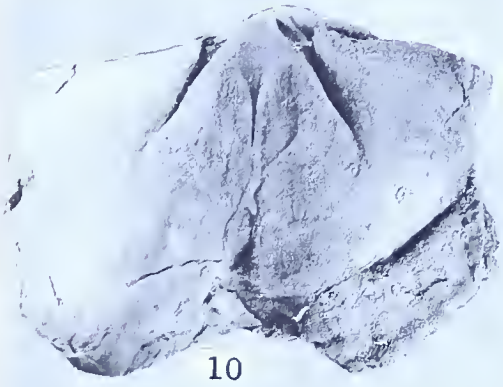
6

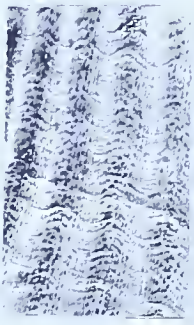

7

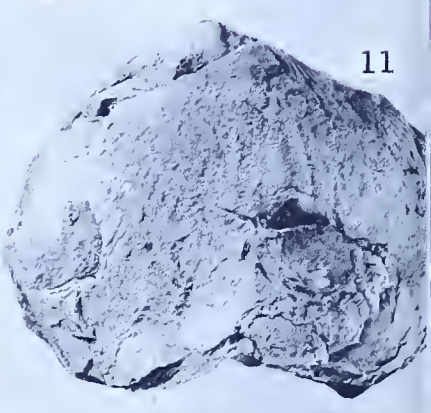

8

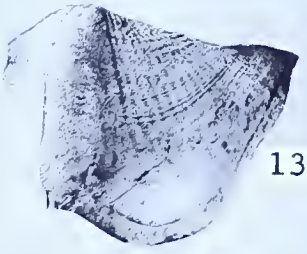

9

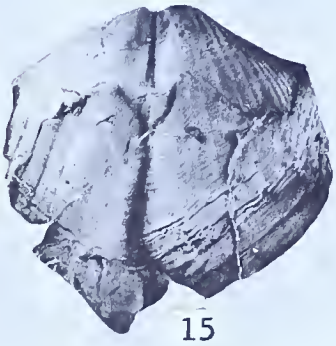
12

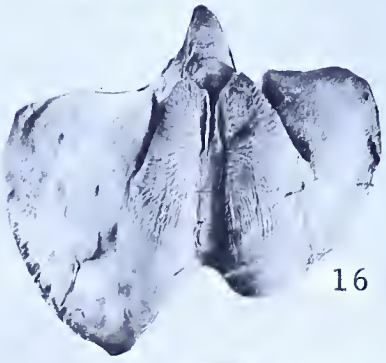

10

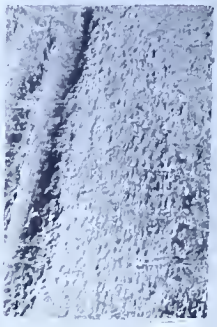

17

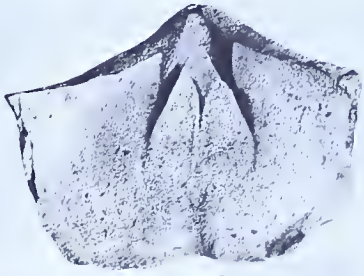

11

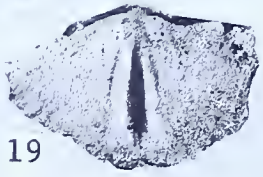

13

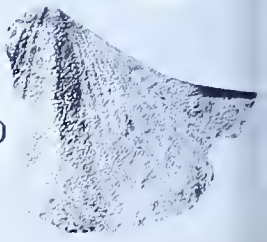

15


16


14


18


19


20

EXPLANATION OF PLATE 12

Figure 1-12—*Mucrospirifer mucronatus* (Conrad).

1. Pedicle valve of specimen showing radial plicae and fine, lamellose concentric ornament; x2. Upper part of Frame Shale Member at Huntingdon.

2. Brachial valve showing nature of ornament and mucronate hinge; x2. Upper part of Frame Shale Member at Huntingdon.

3. Internal mold of mucronate brachial valve showing impressions of bases of brachidia; x1. Upper part of Frame Shale Member at Huntingdon.

4. Posterior view of internal mold of shell displaying impressions of median septum and brachidial bases on brachial valve, and dental lamellae and delthyrial cavity on pedicle valve; x1. Chaneysville Siltstone Member at Websters Mill.

5. External mold of fragment of brachial valve showing very closely spaced concentric lamellae; x2. Chaneysville Siltstone Member at Websters Mill.

6. Internal mold of pedicle valve showing impressions of dental lamellae; x1. Chaneysville Siltstone Member at Websters Mill.

7. External mold of small brachial valve; x1. Upper part of Frame Shale Member at Bedford.

8. Internal mold of specimen shown in figure 7; x1.

9. Internal mold of slightly distorted pedicle valve; x1. Upper part of upper shale member at New Bloomfield.

10. External mold of fragments of pedicle valve showing widely spaced concentric lamellae; x2. Upper part of Frame Shale Member at Newry.

11. Internal mold of brachial valve showing impressions of muscle areas; x1. Upper part of Frame Shale Member at Newry.

12. External mold of brachial valve with unusually angular plicae, and concentric lamellae; x2. Upper part of Montebello Sandstone Member at Rockville.

13-18—*Mediospirifer audaculus* (Conrad).

13. Interior of cardinal area of pedicle valve showing prominent cardinal teeth supported by dental lamellae, and delthyrium nearly filled by apical callosity; x1. Upper part of Frame Shale Member at Newry.

14. Pedicle valve showing moderately deep sulcus, coarse concentric ornament, and widely spaced concentric lamellae; x1. Upper part of Frame Shale Member at Newry.

15. External mold of fragment of brachial valve showing fine concentric lamellae, and impressions of fine grooves along the summits of ribs; x3. Chaneysville Siltstone Member at Everett turnpike.

16. Interior of cardinal area of brachial valve showing striate cardinal process, dental sockets, and hinge plates; x3. Upper part of Frame Shale Member at Newry.

17. Portion of an elongate brachial valve showing moderately prominent fold; x1. Upper part of Frame Shale Member at Newry.

18. Brachial valve bearing relatively wide fold; x1. Upper part of Frame Shale Member at Newry.

19, 20—*Mediospirifer audaculus macronatus* (Hall).

19. Lateral view of shell showing high, nearly erect interarea x1.; Chaneysville Siltstone Member at Fishertown.

20. Posterior view of shell shown in figure 19, displaying high interarea with narrow delthyrium; x1.

21-25—*Mediospirifer bellitropis* Ellison n. sp.

21. Anterior view of brachial valve showing moderately high, unfurrowed fold; x1. Montebello Sandstone Member at Millerstown.

22. Brachial view of specimen shown in figure 21; x1.

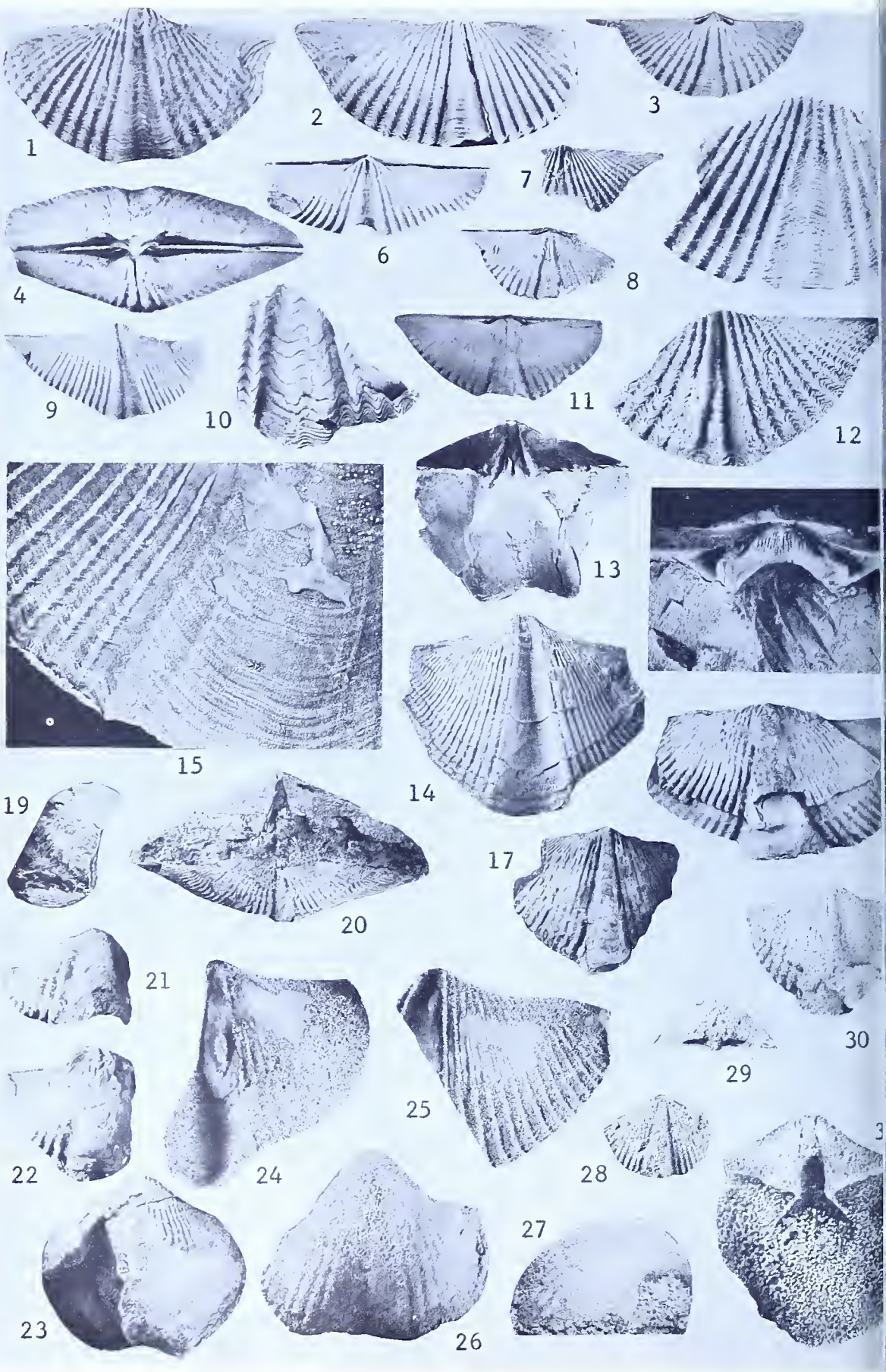
23. Incomplete pedicle valve; relatively deep sulcus not well shown; x1. Montebello Sandstone Member at Millerstown.

24. External mold of brachial valve showing impression of high, unfurrowed fold, and general outline of valve; x2. Montebello Sandstone Member at Millerstown.

25. External mold of brachial valve showing nature of external ornament; x1. Montebello Sandstone Member at Millerstown.

26-31—*Mediospirifer dromgoldi* Ellison n. sp.

26. Pedicle valve showing general shell outline, and broad, shallow sulcus; x2. Lower part of Montebello Sandstone Member at Falling Springs.


1
2
3
4
6
7
8
9
10
11
12
13
15
14
19
20
17
21
22
24
25
28
29
30
23
26
27

EXPLANATION OF PLATE 12—Continued

27. Lateral view of pedicle valve shown in figure 26; x2.

28. Internal mold of brachial valve; x1. Lower part of Montebello Sandstone Member at Falling Springs.

29. Posterior view of internal mold of brachial valve showing valve profile and prominence of fold, as well as impressions of hinge plates; x1. Lower part of Montebello Sandstone Member at Falling Springs.

30. Internal mold of relatively large brachial valve revealing general shell outline, prominent fold with slight median septum in posterior third of valve; x1. Lower part of Montebello Sandstone Member at Falling Springs.

31. Plastiflex cast of interior of pedicle valve showing arched interarea with partially open delthyrium, and dental lamellae; x2. Lower part of Montebello Sandstone Member at Falling Springs.

EXPLANATION OF PLATE 13

Figure 1-5—*Mediospirifer belliplicata* Ellison n. sp.

1. Pedicle valves showing sulcus and suggestion of bifurcation of radial ornament; x2. Chaneysville Siltstone Member at Websters Mill.

2. Internal mold of pedicle valve showing impression of elongate muscle area, dental lamellae, and moderately deep sulcus; x1. Middle part of Montebello Sandstone Member at Marysville.

3. External mold of pedicle valve; x1. Middle part of Montebello Sandstone Member at Marysville.

4. Internal mold of pedicle valve; x1. Middle part of Montebello Sandstone Member at Marysville.

5. Plastiflex cast of specimen shown in figure 4, displaying muscle area, delthyrium nearly closed by deltidial plates that are continuous with dental lamellae; x2.

6-10—*Mediospirifer millerstownensis* Ellison n. sp.

6. Internal mold of pedicle valve showing position of greatest width below hinge; broad, shallow sulcus; x1. Montebello Sandstone Member at Millerstown.

7. Internal mold of brachial valve showing general outline of valve, and broad, low fold; x1. Montebello Sandstone Member at Millerstown.

8. Group of shells showing nature of external ornament; x1. Montebello Sandstone Member at Millerstown.

9. Internal mold of pedicle valve with somewhat more extended beak than specimen in figure 6; x1. Montebello Sandstone Member at Millerstown.

10. Internal mold of pedicle valve showing impressions of dental lamellae and faint impression of muscle area; x1. Montebello Sandstone Member at Millerstown.

11—*Mediospirifer? angustus* (Hall)? Internal mold of pedicle valve showing impressions of dental lamellae, and high, acute interarea; x1. Donation Siltstone Member at Huntingdon.

12, 13—*Fimbrispirifer venustus* (Hall).

12. Internal mold of pedicle valve showing general outline of valve, dental lamellae, sulcus with plicae, and bifurcation of plicae; x2. Chaneysville Siltstone Member at Chaneysville.

13. External mold of shell showing bifurcating plicae and very fine, wavy, concentric striae; x3. Chaneysville Siltstone Member at Chaneysville.

14, 15—*Tylothyris pauliformis* (J. S. Williams).

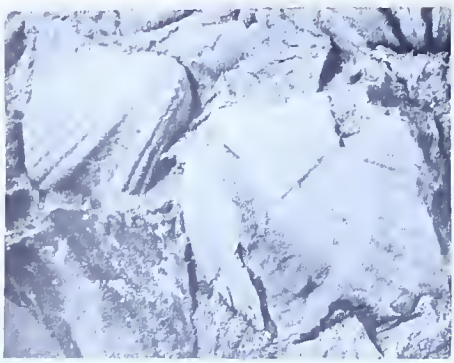
14. Internal mold of brachial valve showing general outline of shell, few plicae with fine, concentric striae, and impressions of hinge plates and fine median septum; x2. Upper part of upper shale member at New Bloomfield.

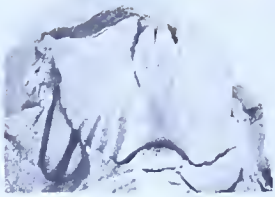
15. External mold of relatively mucronate pedicle valve showing radial plicae, and fine, closely spaced concentric ornament; x2. Upper part of Frame Shale Member at Huntingdon.

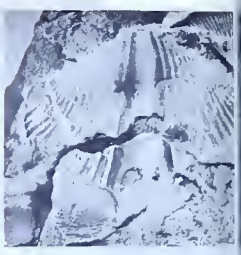
16-18—*"Spirifer" tullius* Hall.

16. Internal mold of pedicle valve revealing impressions of subparallel dental lamellae; x2. Upper part of Frame Shale Member at Bedford.

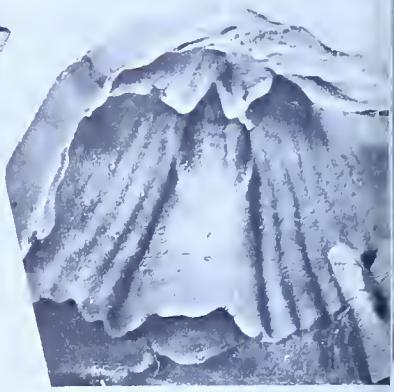
17. Internal mold of pedicle valve shell material on umbo; x2. Upper part of Frame Shale Member at Huntingdon.

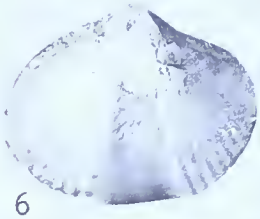

1

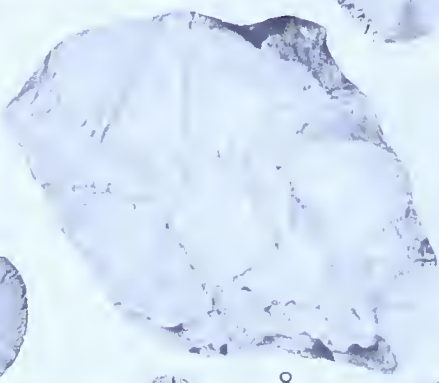

2

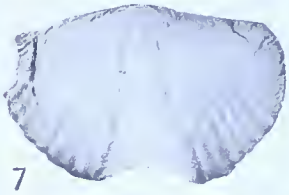


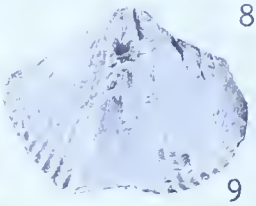
4

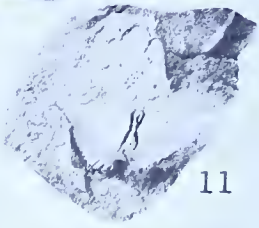


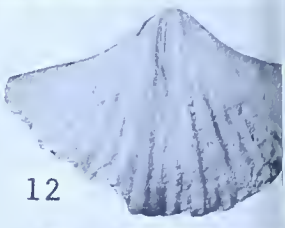

6

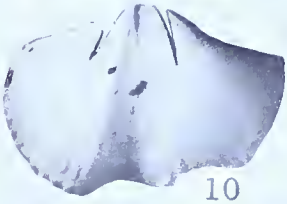

8


7

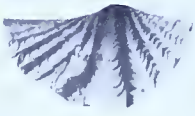

9

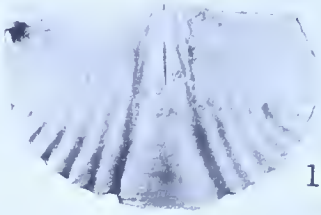

11

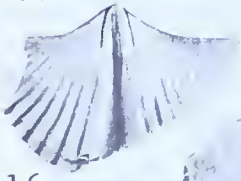

12

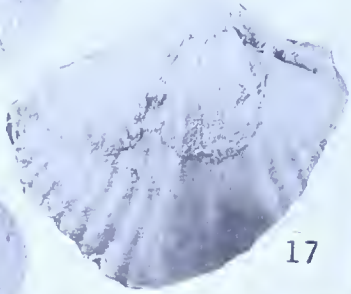

10

14

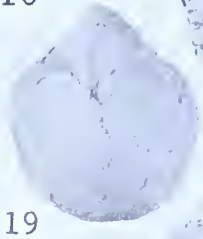

15

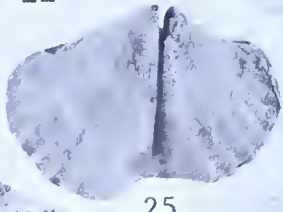

18

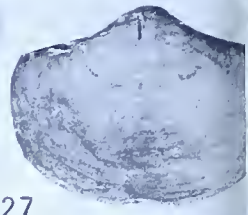

16


17

22
23

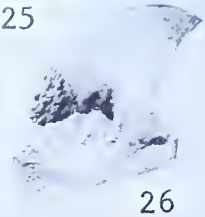

19

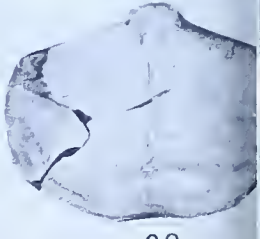

25


27

20

21
24


26


28

EXPLANATION OF PLATE 13—Continued

18. Internal mold of brachial valve showing impressions of thin median septum, fold, and radial plicae; x2. Upper part of Frame Shale Member at Huntingdon.

19-21—*Ambocoelia umbonata* (Conrad).

19. Relatively elongate pedicle valve with sulcus less well developed than normal for species, showing smooth exterior; x2. Tully Member of Harrell Formation at Bedford.

20. Internal mold of pedicle valve showing impressions of muscle area and median sulcus; x2. Upper part of Frame Shale Member at Huntingdon.

21. Brachial view of specimen showing general outline of shell, and slightly convex brachial valve; x2. Tully Member of Harrell Formation at Bedford.

22, 23—*Echinocoelia ambocoeloides* Cooper and Williams.

22. Pedicle valve showing general outline of valve, and very fine concentric ornament; x2. Tully Member of Harrell Formation at New Bloomfield.

23. External mold of pedicle valve showing impressions of fine spines disposed along concentric lamellae; x2. Harrell Formation at Amity Hall.

24-26—*Cyrtina hamiltonensis* (Hall).

24. Brachial view of internal mold of specimen, showing fine median septum and nature of external ornament; x2. Upper part of Frame Shale Member at Huntingdon.

25. Pedicle view of specimen shown in figure 24, displaying long, strong median septum; x2.

26. Lateral view of shell showing relative convexity of valves and high interarea of pedicle valve; x2. Upper part of Frame Shale Member at Huntingdon.

27, 28—*Athyris spiriferoides* (Eaton).

27. Plastiflex cast of pedicle valve showing general outline of shell, and exterior that is smooth except for concentric lamellae; x1. Upper part of Frame Shale Member at Elk Lick Creek.

28. Internal mold of pedicle valve showing general outline of shell and impression of median sulcus; x1. Upper part of Frame Shale Member at Elk Lick Creek.

EXPLANATION OF PLATE 14

Figure 1—*Phthonia sectifrons* (Conrad). Left valve showing fine radial striae that are obsolete on umbo; x3. Upper part of Frame Shale Member at Bedford.

2—cf. *Protomya oblonga* (Hall). Left valve showing large size and nature of ornament; x1. Chaneysville Siltstone Member at Everett turnpike.

3—*Orthonota undulata* Conrad. Specimens showing interfingering rugose concentric ornament, elongate shell outline, and umbonal furrow; x1. Upper part of upper shale member at New Bloomfield.

4, 5—*Orthonota? parvula* Hall.

4. Articulate valves showing general shell outline with forwardly sloping posterior margin, and umbonal carina; x3. Upper part of upper shale member at New Bloomfield.

5. Left valve showing umbonal carina and poorly developed concentric ornament; x3. Lower part of upper shale member at Girtys Notch.

6, 7—*Grammysia arcuata* (Conrad).

6. Left valve showing coarse concentric rugae and general shell outline; x1. Upper part of Frame Shale Member at Huntingdon.

7. Dorsal view of specimen shown in figure 6; x1.

8—*Grammysioidea alveata* (Conrad). Left valve of somewhat distorted specimen showing nearly erect outline and strongly twisted beak; x1. Upper part of Frame Shale Member at Bedford.

9, 10—*Tellinopsis subemarginata* (Conrad).

9. Right valve showing general outline of valve, umbonal furrow, and very fine radial and concentric ornament; x1. Harrell shale at Bedford.

10. External mold of right valve showing very fine concentric ornament; x1. Upper part of upper shale member at Mahantango Creek.

11—*Nucula lirata* (Conrad). External mold of fragment of shell showing step-like concentric rugae and very fine radial lirae; x10. Upper part of upper shale member at New Bloomfield.

EXPLANATION OF PLATE 14—Continued

12, 13—*Nucula bellistriata* (Conrad).

12. Left valve of small specimen showing general shell outline and fine concentric striae; x2. Chaneysville siltstone at Websters Mill.

13. Left valve showing fine, uniformly spaced concentric striae; x2. Lower part of upper shale member at Amity Hall.

14, 15—*Nucula varicosa* Hall.

14. Right valve showing general shell outline and concentric lamellae with smooth interspaces; x2. Lower part of upper shale member at Girtys Notch.

15. Slightly flattened left valve showing concentric lamellae with smooth interspaces; x2. Lower part of upper shale member at Girtys Notch.

16-20—*Nuculites oblongatus* Conrad.

16. Internal mold of right valve showing impression of clavicle; x1. Upper part of Frame Shale Member at Bedford.

17. Internal mold of elongate right valve showing impression of clavicle; x1. Lower part of upper shale member at Girtys Notch.

18. Internal mold of small left valve; x1 Upper part of upper shale member at New Bloomfield

19. Internal mold of large, elongate right valve showing fine concentric ornament, and impression of clavicle; x1. Crooked Creek shale at Huntingdon.

20. Internal mold of elongate left valve showing impression of clavicle; x1. Crooked Creek Shale Member at Huntingdon.

21-23—*Nuculites triqueter* Conrad.

21. Internal mold of right valve showing subtrigonal outline and impression of clavicle; x2. Upper part of upper shale member at New Bloomsfield.

22. Internal mold of small right valve showing impression of clavicle; x2. Lower part of upper shale member at Girtys Notch.

23. Internal mold of large left valve showing fine concentric ornament, and umbonal carina; x2. Upper part of Frame Shale Member at Huntingdon.

24—*Palaeoneilo muta* Hall. Internal mold of right valve showing general shell outline, doubly truncate posterior margin, and regular concentric ornament; x1. Upper part of upper shale member at New Bloomsfield.

25, 26—*Palaeoneilo emarginata* (Conrad).

25. Internal mold of small right valve showing uniformly spaced concentric lamellae; x1. Upper part of upper shale member at Girtys Notch.

26. Internal mold of large right valve showing emarginate posterior, and uniformly spaced concentric lamellae; x1. Upper part of upper shale member at Girtys Notch.

27-37—*Palaeoneilo constricta* (Conrad).

27. Left valve showing general outline of valve with constricted postero-ventral margin, and with finely denticulate hinge line; x2. Lower part of upper shale member at Girtys Notch.

28 Right valve of elongate specimen; x2. Upper part of upper shale member at New Bloomfield.

29. Left valve showing constricted ventral margin, denticulate hinge line, and fine concentric striae; x2. Upper part of Frame shale at Huntingdon.

30. Left valve showing fine concentric ornament; x2. Upper part of Frame Shale Member at Newry.

31. Internal mold of right valve showing finely denticulate hinge line, and fine concentric ornament; x2. Upper part of upper shale member at New Bloomfield.

32. Slightly distorted right valve showing denticulate hinge line; x2. Upper part of Frame Shale Member at Newry.

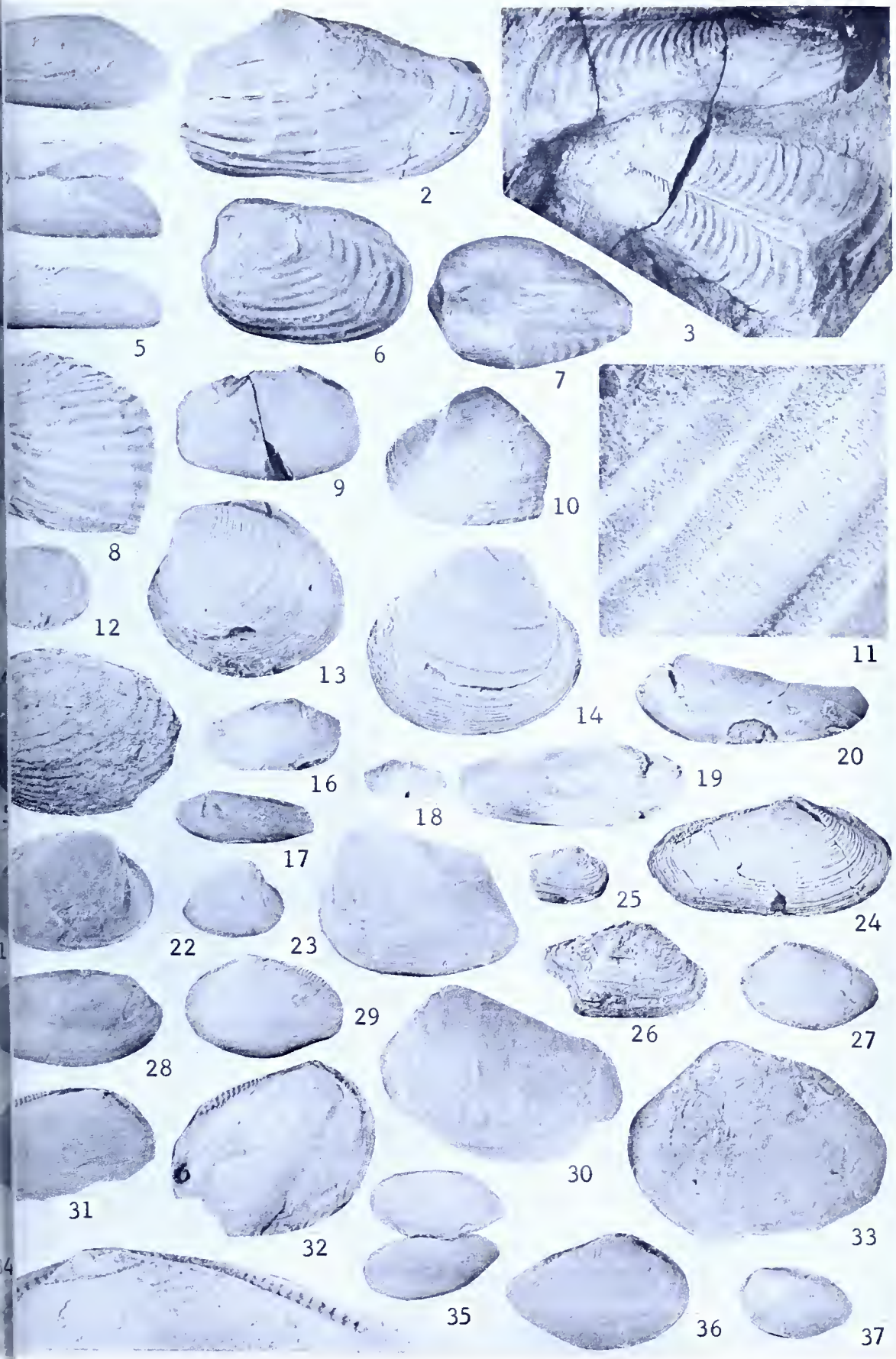
33. Internal mold of relatively large left valve; x2. Upper part of upper shale member at Girtys Notch.

34. Internal mold of hinge line of left valve showing fine denticulation; x4. Upper part of upper shale member at New Bloomsfield.

35. Conjoined valves of small specimen; x2. Upper part of upper shale member at New Bloomfield.

36. Right valve with subnasute posterior margin; x2. Lower part of upper shale member at Girtys Notch.

37. Small left valve displaying constricted ventral margin; x2. Upper part of upper shale member at New Bloomfield.


2
3
5
6
7
8
9
10
11
12
13
14
16
17
18
19
20
22
23
24
25
26
27
28
29
30
31
32
33
35
36
37

EXPLANATION OF PLATE 15

Figure 1, 2—*Palaeoneilo plana* Hall.

1. Left valve showing elongate shell outline and finely denticulate hinge line; x2. Upper part of Frame Shale Member at Huntingdon.

2. Specimen shown in figure 1; x1.

3—*Palaeoneilo tenuistriata* Hall. Right valve showing very fine concentric ornament, and finely denticulate hinge line; x1. Upper part of Montebello Sandstone Member at Rockville.

4, 5—*Palaeoneilo perplana* Hall.

4. Nearly complete right valve showing truncate posterior margin, umbonal carina, and widely spaced lamellae on umbonal slope; x1. Upper part of upper shale member at Girtys Notch.

5. Fragment of external mold of left valve showing umbonal carina, and concentric lamellae that are obsolete along carina; x1. Chaneysville Siltstone Member at Everett turnpike.

6—*Palaeoneilo filosa* (Conrad)? Internal mold of right valve showing umbonal carina nearly along hinge, and fine, uniformly spaced concentric striae; x2. Upper part of upper shale member at Girtys Notch.

7—*Palaeoneilo fecunda* Hall. Left valve displaying fine concentric striae and few lamellae; x2. Upper part of Frame Shale Member at Elk Lick Creek.

8—*Nuculana diversa* (Hall). Right valve showing general shell outline, nasute posterior, and fine, uniformly spaced concentric striae; x2. Upper part of upper shale member at Girtys Notch.

9—*Parallelodon hamiltoniae* (Hall). Right valve showing widely spaced concentric lamellae, double furrows along hinge, and very fine radial lirae; x1. Upper part of Frame Shale Member at Huntingdon.

10, 11—*Cornellites flabella* (Conrad). Two left valves showing general shell outline, short anterior ear, broad posterior wing, and widely spaced radial plicae with secondary costae between; x1. Upper part of Montebello Sandstone Member at Rockville.

12—*Leiopteria laevis* (Hall). Left valve showing nearly erect outline, nearly equally developed ear and wing, and smooth exterior; x2. Lower part of Chaneysville Siltstone Member at Websters Mill.

13-16—*Leiopteria* spp.

13. Left valve of prosocline specimen with weakly developed ear and wing, and showing finely developed concentric ornament; x1. Upper part of Frame Shale Member at Bedford.

14. External mold of acline right valve with broad, flat wing and small anterior ear; x2. Upper part of upper shale member at New Bloomfield.

15. External mold of acline left valve with broad wing; x1. Upper part of Chaneysville Siltstone Member at Chaneysville.

16. External mold of left valve of specimen showing prominent concentric striae; x1. Upper part of Frame Shale Member in an exposure near Roseburg, in Perry Co.

17, 18—*Glytodesma erectum* (Conrad).

17. Internal mold of hinge area of left valve showing impressions of lateral teeth; x1. Chaneysville Siltstone Member at Websters Mill.

18. External mold of specimen shown in figure 17 showing extended anterior ear; broad, flat wing; and fine concentric ornament; x1.

19, 20—*Leptodesma rogersi* Hall.

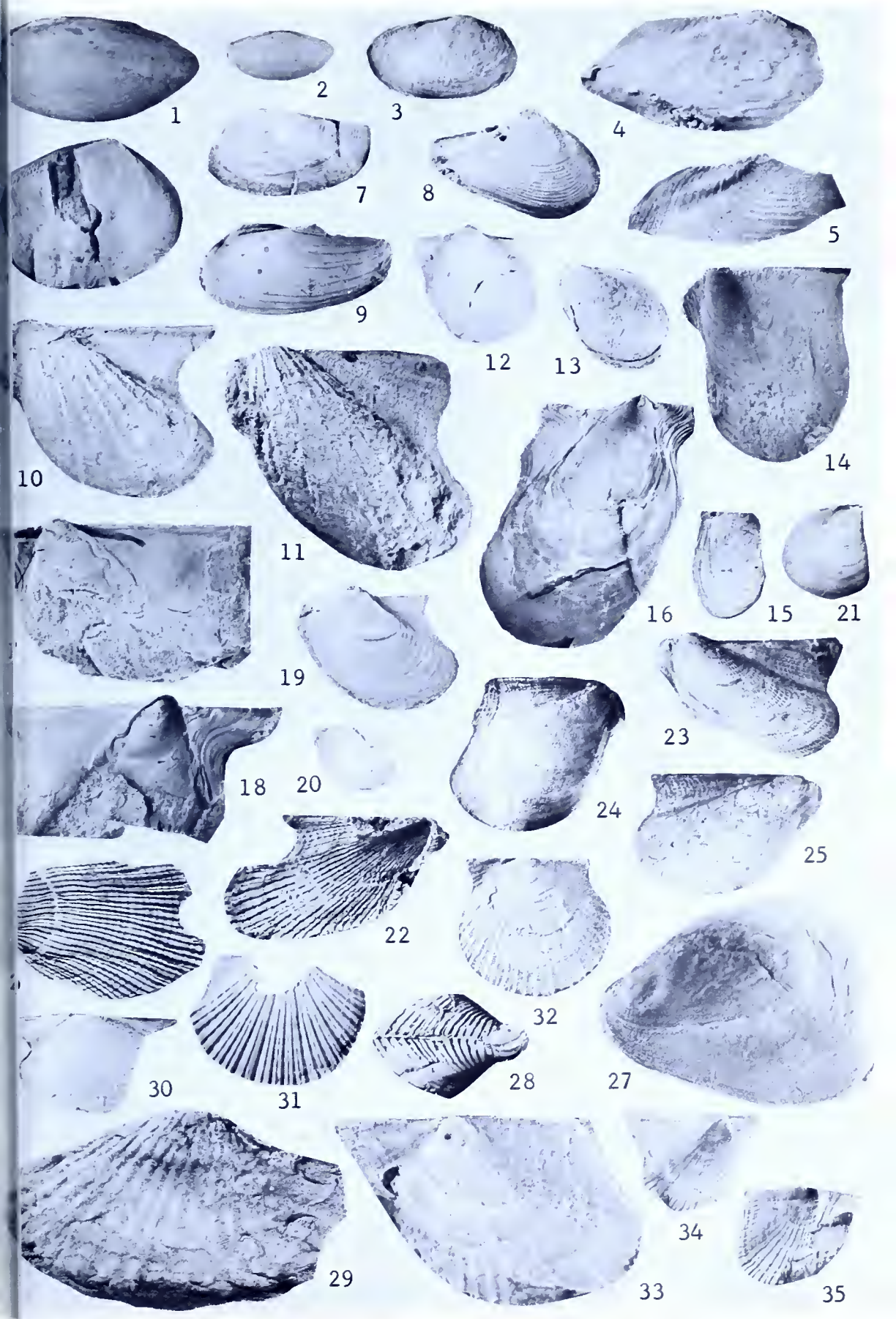
19. Left valve showing prosocline outline, small posterior wing, anteriorly directed ear, and concentric wrinkles; x4. Gander Run Member at Bedford.

20. Left valve of small specimen with large anterior ear; x4. Gander Run Shale Member at Bedford.

21—*Pterochaenia fragilis* (Hall). Right valve showing nearly erect, subtrigonal outline, and small posterior wing; x4. Lower part of upper shale member at Girtys Notch.

22-26—*Actinopteria decussata* (Hall).

22. External mold of left valve showing strongly prosocline outline, and


1
2
3
4
5
7
8
9
10
11
12
13
14
15
16
18
19
20
21
22
23
24
25
27
28
29
30
31
32
33
34
35

EXPLANATION OF PLATE 15—Continued

decussate ornament; x2. Donation Siltstone Member at Huntingdon.

23. Left valve showing small anterior ear and broad wing, and decussate ornament; x2. Upper part of Frame Shale Member at Huntingdon.

24. Right valve showing absence of decussate ornament except on posterior wing; x1. Upper part of Frame Shale Member at Huntingdon.

25. Right valve showing absence of decussate ornament except on posterior wing; x1. Upper part of upper shale member at Girtys Notch.

26—Fragment of external mold showing dominance of radial over concentric ornament; x2. Upper part of Frame Shale Member at Elk Lick Creek.

27—*Modiella pygmaea* (Conrad). External mold of right valve showing general shell outline and fine concentric striae; x6. Upper part of upper shale member at New Bloomfield.

28—*Conocardium concinnum* Hall. Ventral view of internal mold of conjoined valves showing strong radial ornament and general shell profile; x2. Upper part of Frame Shale Member at Huntingdon.

29—*Conocardium normale* Hall? Incomplete left valve showing strong radial ornament; x1. Gander Run Shale Member at Martins Gap.

30—*Aviculopecten bellus* (Conrad). Left valve showing mucronate anterior ear and posterior wing, alternating fine and very fine radial striae, and fine concentric striae; x2. Backbone Ridge Siltstone Member at Martins Gap.

31—*Aviculopecten insignis* Hall. Right valve showing part of posterior wing, and strong, bifurcating radial costae; x2. Upper part of Frame Shale Member at Huntingdon.

32—*Aviculopecten equilatera* (Hall). Left valve showing nearly acline, suborbicular outline, with small ear and wing, and intercalation of radial costellae; x6. Upper part of upper shale member at New Bloomfield.

33-35—*Pterinopecten hermes* Hall?

33. Left valve showing subrhomboidal outline, broad and flat anterior ear and posterior wing, and widely spaced radialstriae; x6. Upper part of upper shale member at New Bloomfield.

34, 35. External mold of left valves showing general shell outline and radial striae; x4. Upper part of upper shale member at Girtys Notch.

EXPLANATION OF PLATE 16

Figure 1-3—*Pterinopecten (peudaviculopecten) princeps* (Conrad).

1. Large, nearly acline left valve showing posterior wing and parvicostellate ornament; x1. Middle part of Frame Shale Member at Huntingdon.

2. Large, somewhat prosocline left valve showing parvicostellate ornament; x1. Chaneysville Siltstone Member at Chaneysville.

3. Small, nearly acline left valve showing anterior ear and part of posterior wing, and parvicostellate ornament; x2. Upper part of upper shale member at New Bloomfield.

4-6—*Mediomorpha concentrica* (Conrad).

4. Posterior half of right valve showing uniformly spaced concentric striae; x1. Upper part of Montebello Sandstone Member at Rockville.

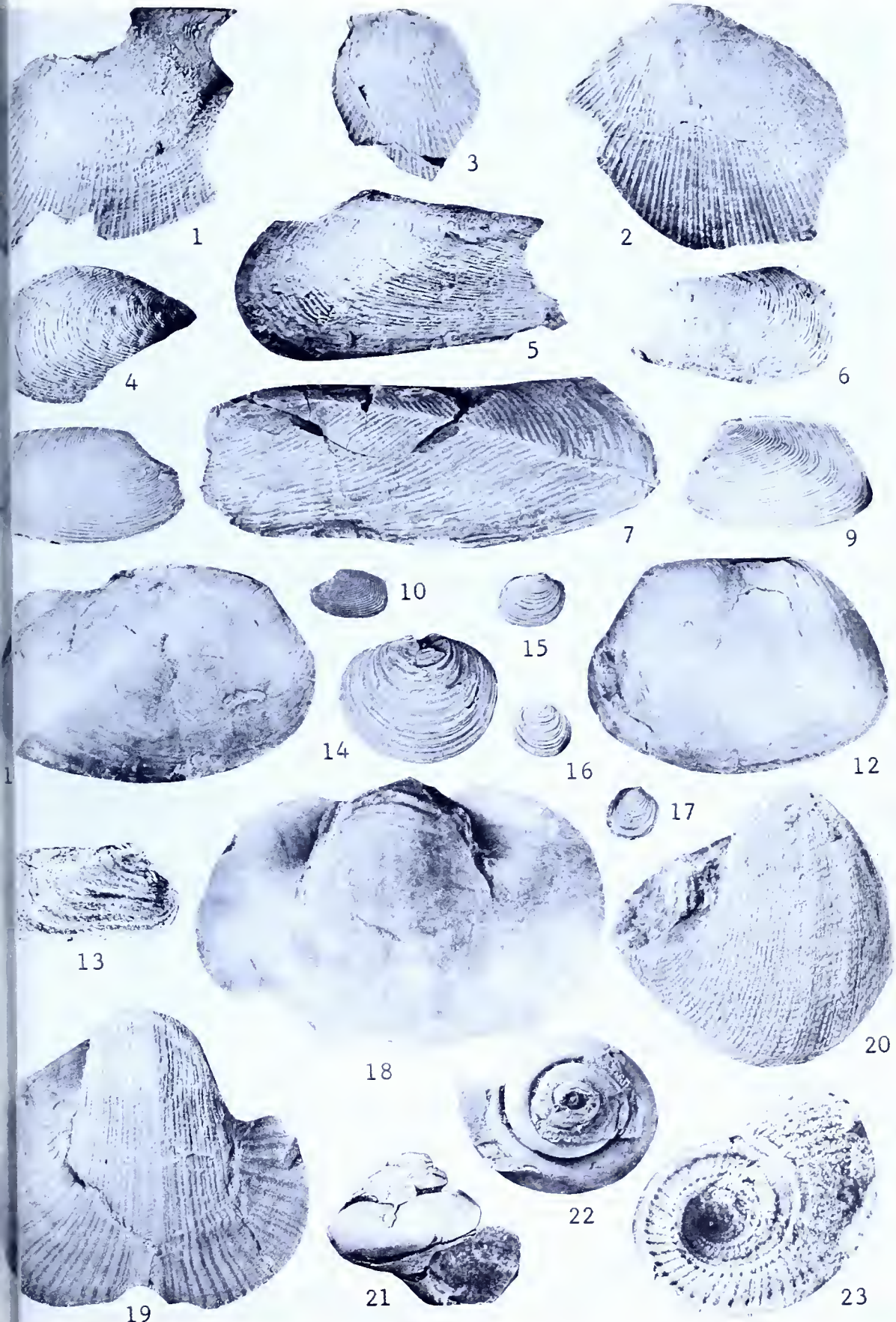
5. Nearly complete right valve showing elongate shell outline, and fine, uniformly spaced concentric striae; x1. Upper part of Frame Shale Member at Elk Lick Creek.

6. Left valve showing general shell outline and regularly disposed concentric striae; x1. Chaneysville Siltstone Member at Websters Mill.

7—*Goniophora hamiltonensis* (Hall). Large left valve showing elongate shell outline, somewhat constricted ventral margin, slightly irregular concentric striae, and sharp umbonal carina; x1. Crooked Creek Shale Member at Huntingdon.

8-10—*Cypricardella bellastriata* (Conrad).

8. Right valve showing general shell outline, appressed beak, truncate posterior margin, and uniformly spaced concentric striae that bend dorsally on umbonal slope; x1. Upper part of upper shale member at Amity Hall.


1
3
2
5
4
6
7
9
10
15
14
16
12
17
13
18
20
22
19
21
23

EXPLANATION OF PLATE 16—Continued

9. Left valve showing shell outline and nature of external ornament; x1. Upper part of Frame Shale Member at Huntingdon.

10. Small left valve showing extended anterior margin and fine concentric ornament; x1. Lower part of upper shale member at Girtys Notch.

11, 12—*Cypricardella tenuistriata* (Hall).

11. Right valve showing large size, general shell outline, and surface that is smooth except for faint concentric striae; x1. Upper part of upper shale member at Mahantango Creek.

12. Left valve showing large size, general shell outline, and nearly smooth surface; x1. Upper part of upper shale member at Mahantango Creek.

13—*Cypricardinia indenta* (Conrad). External mold of left valve showing low anterior, slightly constricted ventral margin, and widely spaced concentric lamellae; x4. Upper part of upper shale member at New Bloomfield.

14-17—*Paracyclas lirata* (Conrad).

14. Valve showing nearly circular outline and coarse concentric rugae; x1. Lower part of upper shale member at Girtys Notch.

15. Small right valve showing subrhomboidal outline and fasciculate concentric rugae; x1. Lower part of upper shale member at Girtys Notch.

16. Small left valve with subcircular outline showing fasciculate concentric rugae; x1. Lower part of Chaneysville Siltstone Member at Websters Mill.

17. Small right valve showing fasciculate concentric rugae; x1. Lower part of upper shale member at Girtys Notch.

18—*Ptomatis patulus* (Hall). Flattened shell showing bellerophontoid form and smooth surface; x1. Chaneysville Siltstone Member at Everett turnpike.

19—*Bucanopsis leda* (Hall). Flattened shell showing bellerophontoid form, well developed selenizone, and radial costae and transverse striae; x2. Upper part of Frame Shale Member at Huntingdon.

20—*Crenistriella crenistra* (Hall). Shell showing finely nodose ornament produced in association with strong radial anl fine spiral striae; x4. Lower part of Frame Shale Member at Fishertown.

21-23—*Bembexia sulcomarginata* (Conrad).

21. Internal mold of shell showing general profile of whorls, and dextral coiling; x1. Crooked Creek Shale Member at Huntingdon.

22. Apical view of specimen shown in figure 21; x1.

23. External mold of upper surface of whorls showing impressions of fine radial striae terminating in fine nodes; x2. Montebello Sandstone Member at Mahantango Creek.

EXPLANATION OF PLATE 17

Figure 1—*Bembexia capillaria* (Conrad). Fragment of one whorl showing fine radial striae along which concentric rows of low nodes are developed; x3. Upper part of upper shale member at New Bloomfield.

2-4—*Bembexia laevis* Ellison n. sp.

2. Apical view of internal mold showing dextral coiling; x1. Lower part of upper shale member at Amity Hall.

3. Apical view of internal mold showing 3 whorls and dextral coiling; x1. Lower part of upper shale member at Amity Hall.

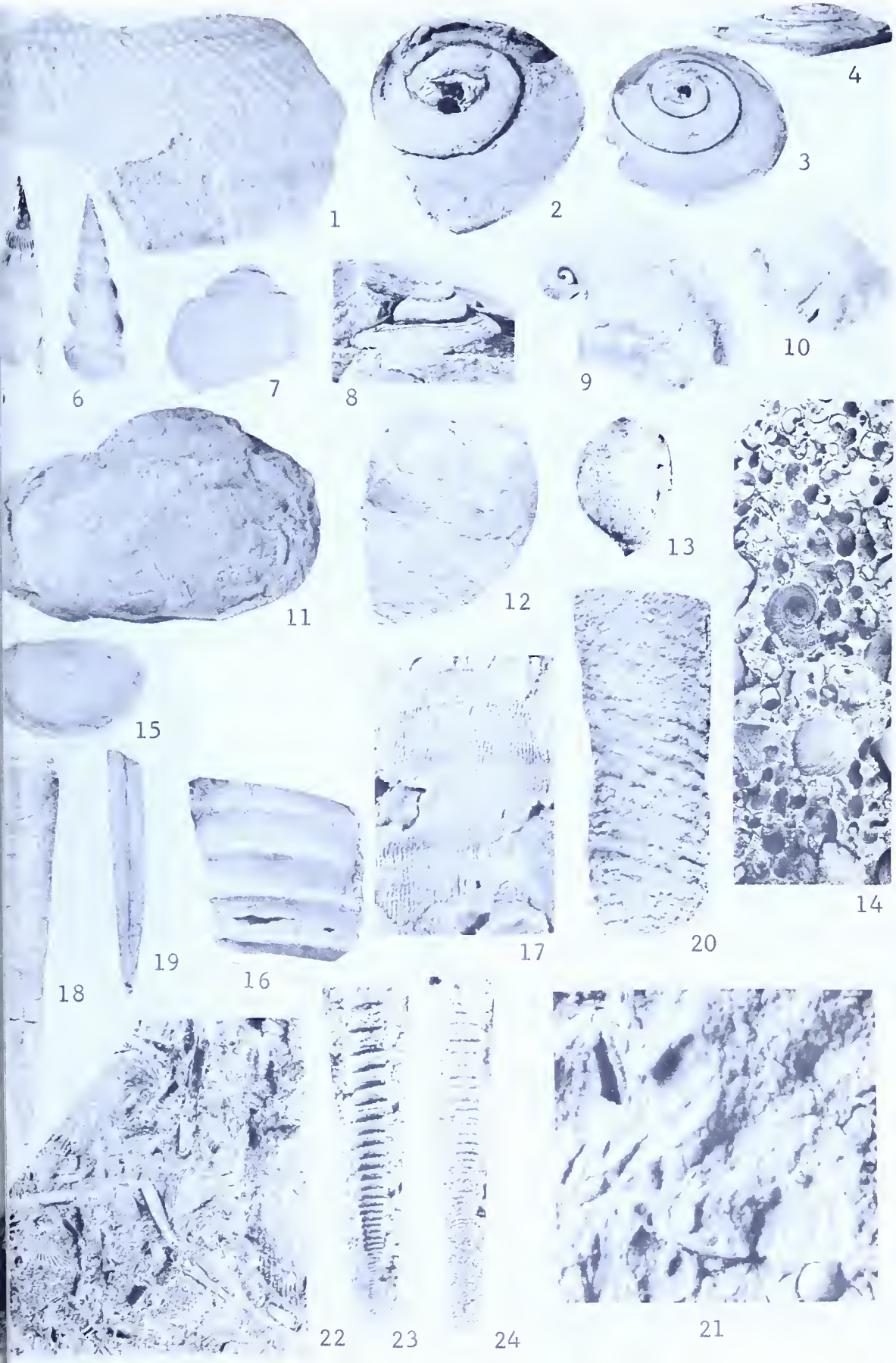
4. Lateral view of shell showing flattened profile; x1. Lower part of upper shale member at Amity Hall.

5, 6—*Loxonema delphicola* Hall.

5. External mold of shell showing turretted profile, arcuate radial striae, and narrow concentric band along spiral sutures; x1. Gander Run Shale Member in an exposure near East Freedom in Blair Co.

6. External mold of shell showing turretted profile, arcuate radial striae, and narrow concentric band along spiral sutures; x1. Lower part of upper shale member at New Bloomfield.

7. *Holopea macrostomus* Hall? Shell showing relatively large body whorl and small spire, and weakly developed radial striae; x1. Upper part of Montebello Sandstone Member at Rockville.


1
2
3
4
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24

EXPLANATION OF PLATE 17—Continued

8—*Cyclonema* sp. Shell showing well developed spiral ornament; x2. Upper part of Frame Shale Member at Elk Lick Creek.

9, 10—*Platyceras sp.* Two internal molds showing rapidly expanding coiling with tightly coiled spire; x2. Chaneysville Siltstone Member at Fishertown.

11—*Platyceras (Platyostoma) euomphaloides* Hall. Shell showing relatively large body whorl and small spire, and fine concentric ornament; x1. Upper part of Montebello Sandstone Member at Rockville.

12—*Naticonema lineata* (Conrad). Apical view of shell only faintly showing fine radial ornament; x1. Chaneysville Siltstone Member at Websters Mill.

13, 14—*Ianthinopsis?* sp.

13. External mold of extremely large shell showing relatively large body whorl and small spire; x1. Montebello sandstone at Mahantango Creek.

14. Flood of external and internal molds of small shells, including molds of pelecypods and *Bembexia sulcomarginata;* x1. Montebello Sandstone Member at Mahantango Creek.

15—*Striacoceras typum* (Saemann)? Incomplete internal mold showing impressions of septum and centrally located siphuncle; x1. Upper part of Frame Shale Member at Huntingdon.

16, 17—*Spyroceras nuntium* (Hall)?

16. Internal mold of shell showing constriction of chambers between septa; septa somewhat more widely spaced than normal for species; x1. Chaneysville Siltstone Member at Everett turnpike.

17. External mold of surface of shell showing impressions of septal ridges, and very fine longitudinal striae; x3. Upper part of upper shale member at Girtys Notch.

18, 19—*Bactrites? aciculum* (Hall).

18. Shell showing elongate conical outline, median cleft, and faint suggestion of septa; x1. Lower part of upper shale member at Girtys Notch.

19. Shell of more common size than that in figure 18, showing shell outline and median cleft; x1. Lower part of upper shale member at Girtys Notch.

20—*Coleolus gracilis* Hall? Fragment of external mold showing slightly dipping concentric ornament: x7. Upper part of upper shale member at Mahantango Creek.

21—*Styliolina bellistriata* Ellison n. sp. External mold of shell showing median cleft and weak longitudinal striae; x17. Upper part of upper shale member at New Bloomfield.

22-24—*Tentaculites attenuatus* Hall.

22. Numerous internal molds of shells; fragment of shell at bottom, left of center of photo, showing 2 of the concentric annulae; x2. Montebello Sandstone Member at Millerstown.

23. External mold of shell showing fine concentric annulae between more prominent concentric annulae; x4. Upper part of Montebello Sandstone Member at Rockville.

24. External mold of shell showing less regularly spaced concentric annulae than shown by specimen in figure 23; x4. Montebello Sandstone Member at Falling Springs.

EXPLANATION OF PLATE 18

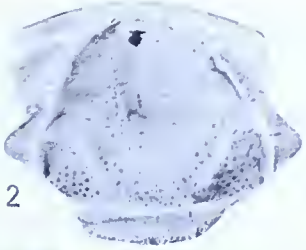
Figure 1—*Proetus rowi* (Green). Cephalon and nearly complete thorax showing isolated lateral lobes of glabella, cephalic border, holochroal eyes, and finely pustulos surface; x2. Upper part of Frame Shale Member at Huntingdon.

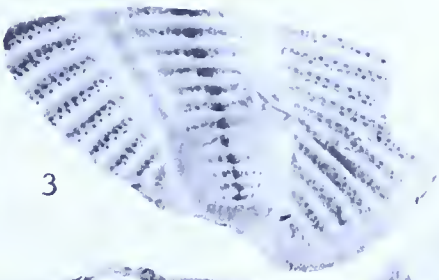
2, 3—*Dechenella (Monodechenella) macrocephala* (Hall).

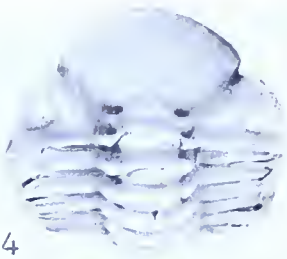
2. External mold of cranidium showing impressions of glabella with isolated lateral lobes, occipital node, and coarsely pustulose surface; x2. Upper part of Crooked Creek Shale Member at Martins Gap.

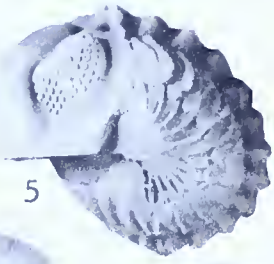
3. Externai mold of pygidium showing nodes on segments of axial lobe, pustulose surface on summits of segments, and marginal border; x2. Upper part of Crooked Creek Shale Member at Martins Gap.

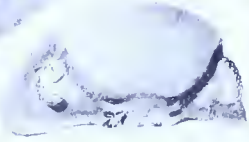
1


2

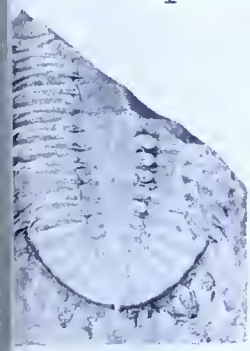

3


4

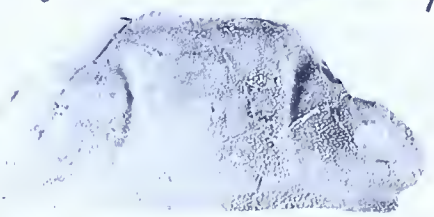

5


6

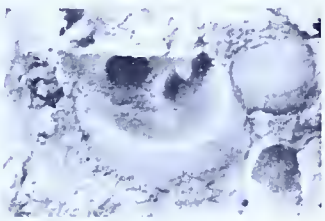
7

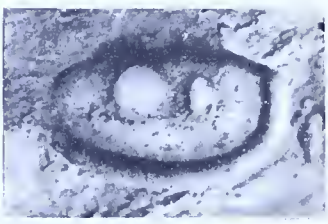

8

9

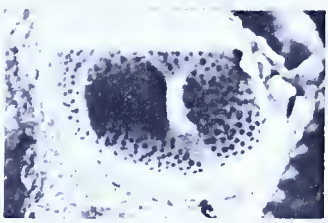

10

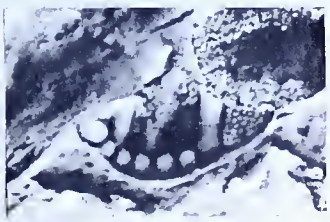
11

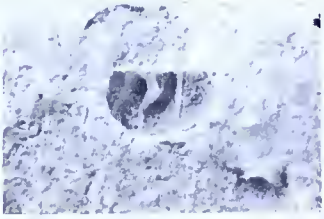

12


13

14


15


16


17

18

EXPLANATION OF PLATE 18—Continued

4-7—*Phacops rana* (Green).

4. Dorsal view of enrolled specimen showing prominent frontal lobe, lateral furrows reduced to 2 pair of pits, and schizochroal eyes; x2. Upper part of Frame Shale Member at Newry.

5. Lateral view of specimen shown in figure 4, showing nature of enrollment, and vincular furrow along ventral margin of cephalon; x2.

6. Cephalon showing transverse outline, broad frontal lobe, and schizochroal eyes; x1. Upper part of Frame Shale Member at Huntingdon.

7. Incomplete cephalon showing pustulose surface of frontal lobe; x1. Tully Member of Harrell Formation at Bedford.

8—*Greenops (Greenops) boothi* (Green). Internal mold of thorax, pygidium, and 1 genal spine of cephalon showing broad, flat spines that fringe pygidium; x2. Lower part of upper shale member at Girtys Notch.

9—*Greenops (Greenops) boothi* var. *calliteles* (Green). Internal mold of pygidium showing slender spines and short terminal spine that fringe pygidium; x2. Upper part of upper shale member at New Bloomfield.

10, 11—*Trimerus (Dipleura) dekayi* Green.

10. Cephalon showing transverse outline, subquadrate glabella lacking lobation, bases of eye stalks, and finely pustulose surface, x1. Upper part of Frame Shale Member in an exposure near Everett, in Bedford Co.

11. Nearly complete thorax showing pleural and interpleural furrows; x1. Upper part of upper shale member at Mahantango Creek.

12—*Hollinella tricollina* (Ulrich). External mold of left plenate valve showing impressions of large penantiplenate lobe, 2 closely situated adplenate lobes, and the broad, flat frill along free edge of valve; x16. Upper part of upper shale member at New Bloomfield.

13, 14—*Hollinella* cf. *H. sella* Stover. Two internal molds of right plenate valves showing the single large subspherical lobe and the smaller subvertical lobe; x16. Upper part of upper shale member at Girtys Notch.

15—*Adelphobolbina medialis* Stover. External mold of left plenate valve showing impressions of deep medio-adplenate sulcus, and shallow antiplenate sulcus, as well as the unevenly tuberculose surface; x16. Upper part of Frame Shale Member at Huntingdon.

16-18—*Ctenoloculina cicatricosa* (Warthin).

16. External mold of free edge of valve showing impressions of loculi along ventral margin, smooth sulci, and reticulate lobes; x16. Upper part of Frame Shale Member at Huntingdon.

17. External mold of small right plenate valve showing 3 smooth, strong sulci, and reticulate lobes; x16. Upper part of upper shale member at New Bloomfield.

18. Internal mold of right plenate valve showing trisulcation and quadrilobation; x16. Upper part of upper shale member at Girtys Notch.

EXPLANATION OF PLATE 19

Figure 1, 2—*Ulrichia spinifera* Coryell and Malkin?

1. External mold of right plenate valve showing impressions of 2 small lobes closely situated along dorsal margin, and reticulate surface; x16. Upper part of upper shale member at New Bloomfield.

2. Internal mold of left plenate valve showing 2 small dorsal lobes; x16. Upper part of upper shale member at New Bloomfield.

3, 4—*Hibbardia lacrimosa* (Swartz and Oriel).

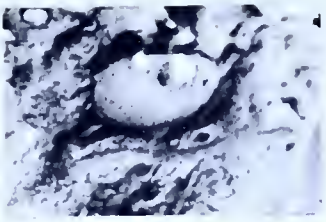
3. Internal mold of right plenate valve showing truncate dorsal margin and bilobaste surface; x16. Upper part of upper shale member at New Bloomfield.

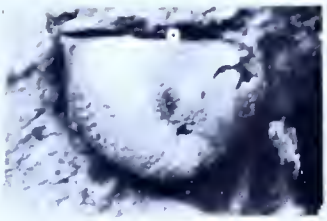
4. External mold of specimen shown in figure 3 showing impression of reticulate surface and tear-drop-shaped pit near center of valve; x16.

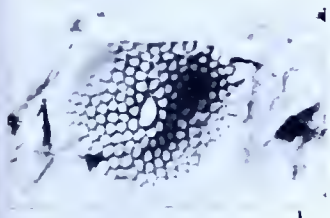
5, 6—*Ponderodictya punctulifera* Hall.

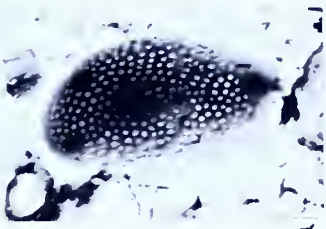
5. External mold of left valve showing coarsely reticulate surface and 2 posterior spurs; x16. Lower part of upper shale member at New Bloomfield.

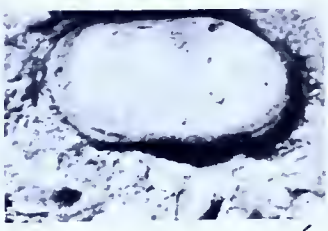
1

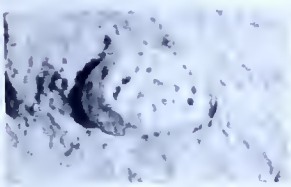

2

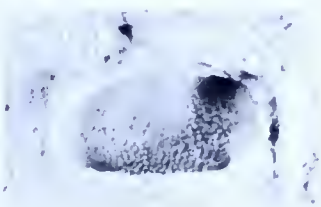

3

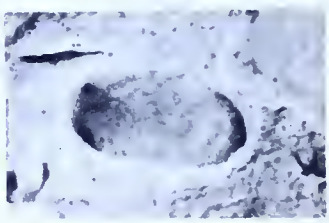

4


5


6

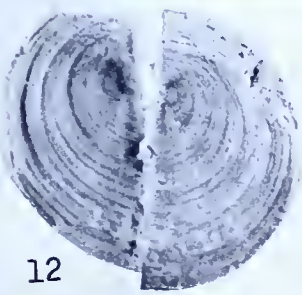

7


8

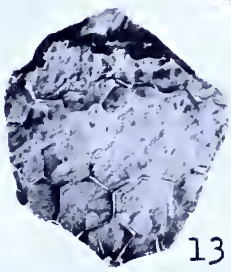

9

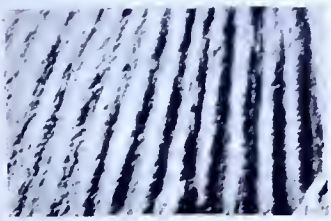
10

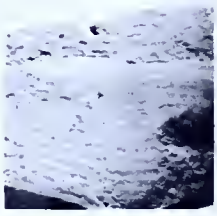
11


12

14


13


15


16

EXPLANATION OF PLATE 19—Continued

6. Internal mold of left? valve showing impression of overlap?; x16. Lower part of upper shale member at New Bloomfield.

7—*Octonaria bifurcata* Stover. Internal mold of left valve illuminated from right to show anterior declivity and disposition of crossbars and pits; x18. Upper part of upper shale member at New Bloomfield.

8—*Quasillites* sp. External mold of left valve illuminated from right to show pit marking position of antero-ventral spine, and showing reticulate ornament and median spot; x17. Upper part of upper shale member at New Bloomfield.

9—*Bufina biconuta* (Ulrich). External mold of left plenate valve showing positions of two posterior spines, and crescentic carina along anterior margin; x20. Upper part of upper shale member at New Bloomfield.

10, 11—*Euglyphella numismoides* Swartz and Oriel. Two external molds of left plenate valves showing impressions of deeply incise furrows that are interrupted by fine crossbars, and showing general outline of valve; x16. Upper part of upper shale member at New Bloomfield.

12—*Schizodiscus capsa* Clarke. External molds of conjoined valves showing beaks situated behind anterior margin, and fine concentric ornament; x6. Upper part of upper shale member at New Bloomfield.

13, 14—*Technocrinus?* sp.

13. Portion of dorsal cup showing arrangement of calical plates; x1. Upper part of Frame Shale Member at Huntingdon.

14. Internal mold of inside surface of calical plates; x1. Upper part of Frame Shale Member at Huntingdon.

15—*Retichonetes marylandicus* (Prosser and Kindle). External mold of brachial valve showing fine striae developed on radiating ribs; x10. Chaneysville Siltstone Member at Everett Turnpike.

16—*Striacoceras typum* (Saemann)? Cast of exterior showing circumferential striae; x2.5. Upper part of Frame Shale Member at Huntingdon.

603

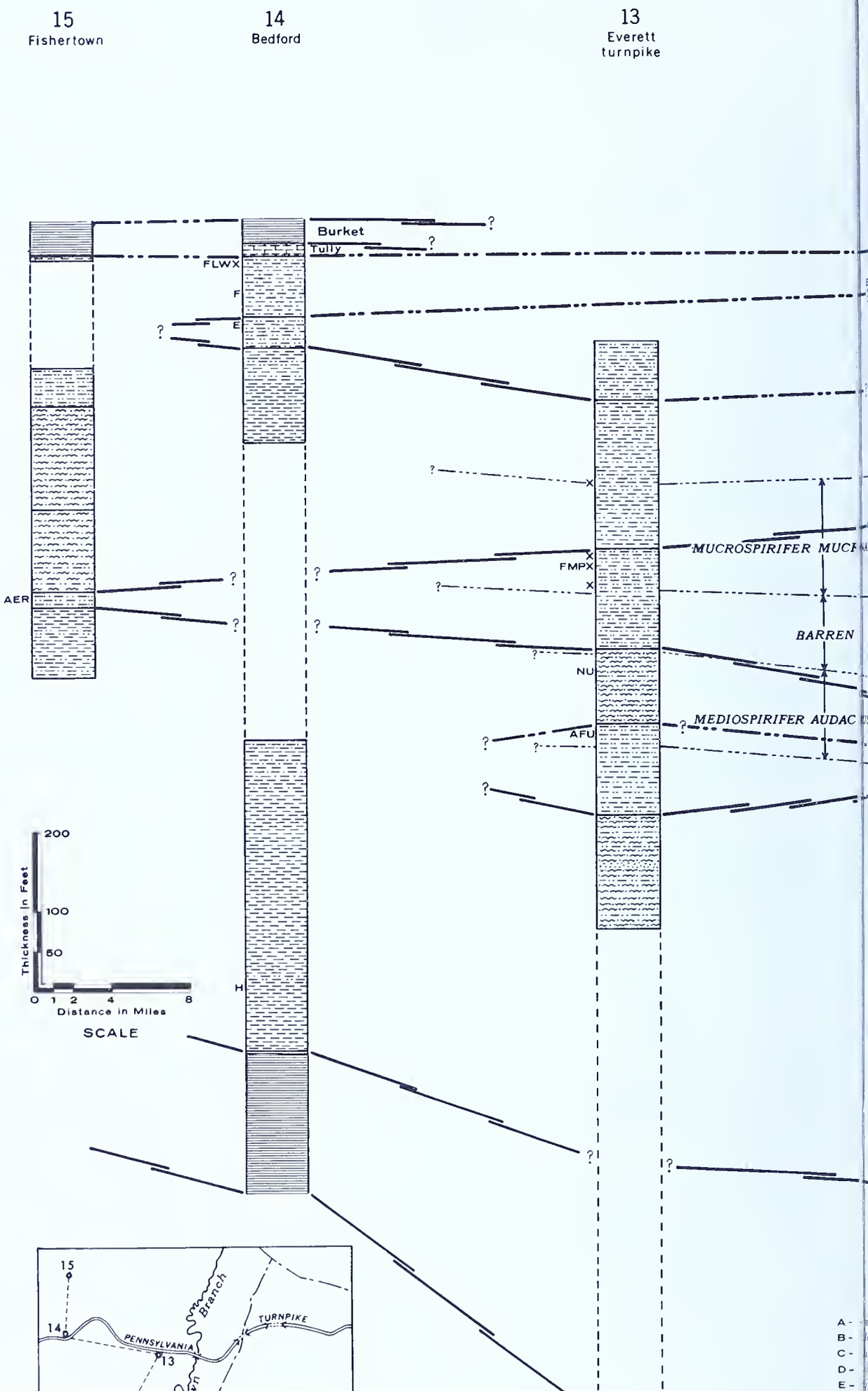
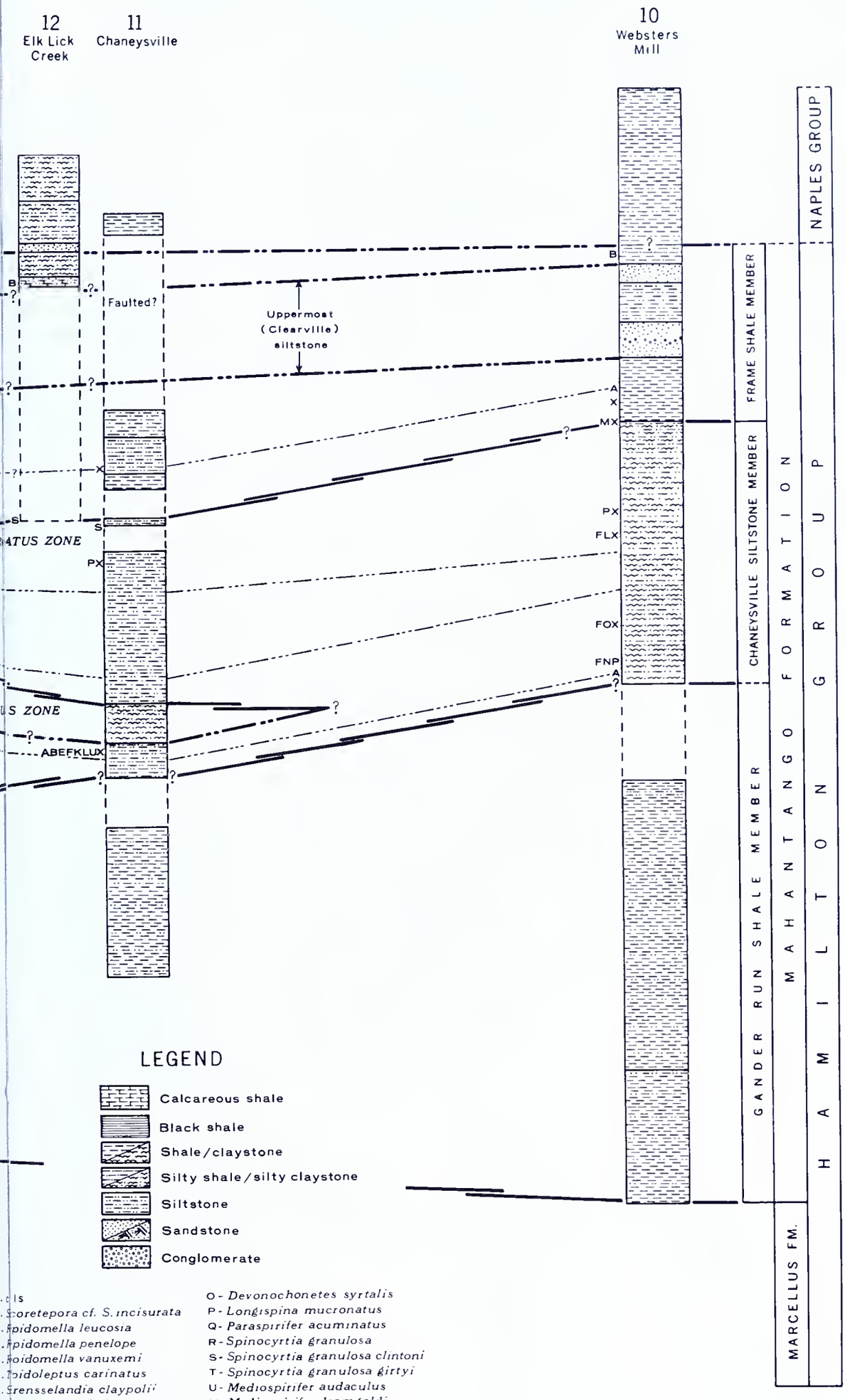


Plate 2. Stratigraphic relationships of the Mahan



ntngo Formation in Bedford and Fulton Counties.

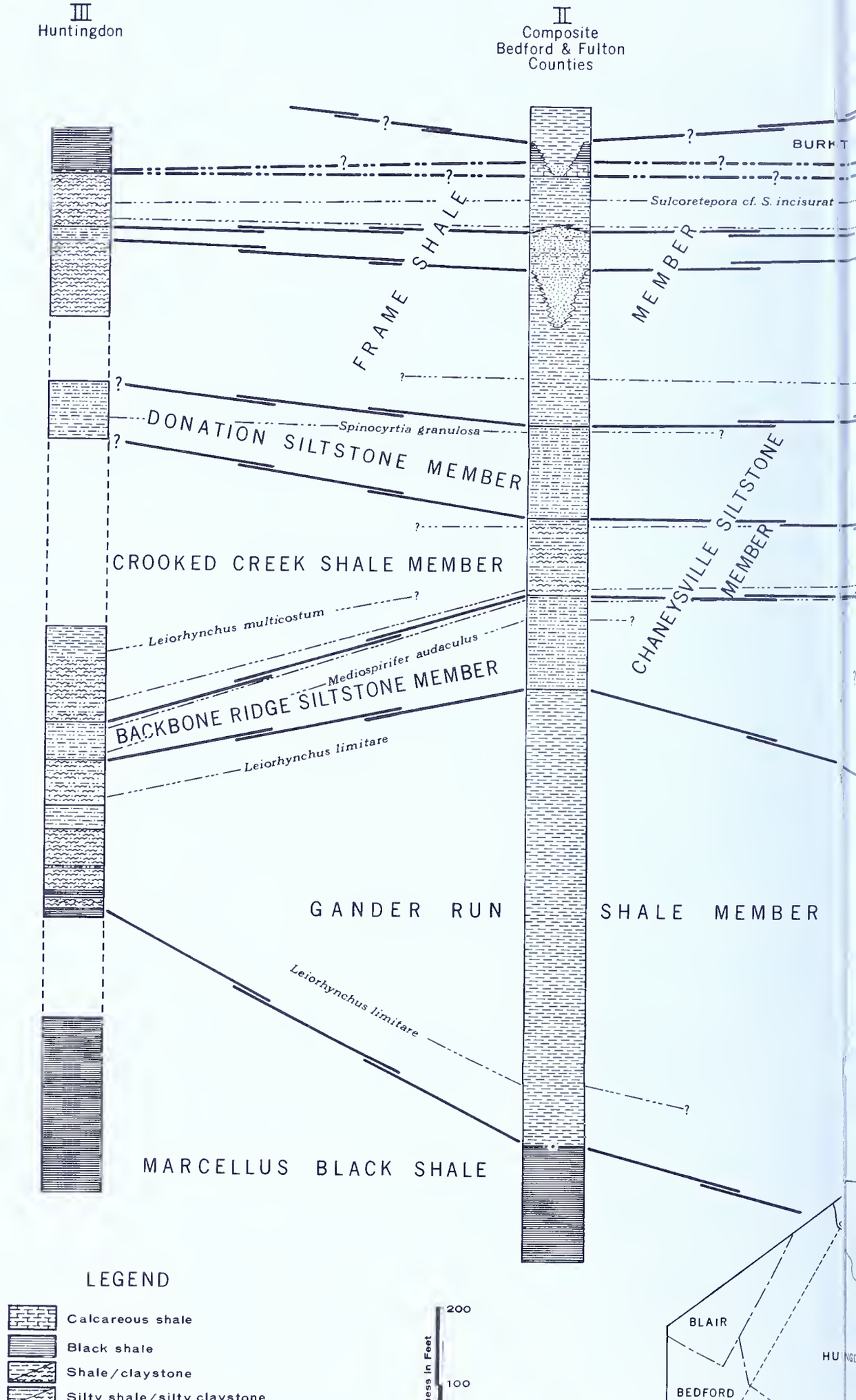
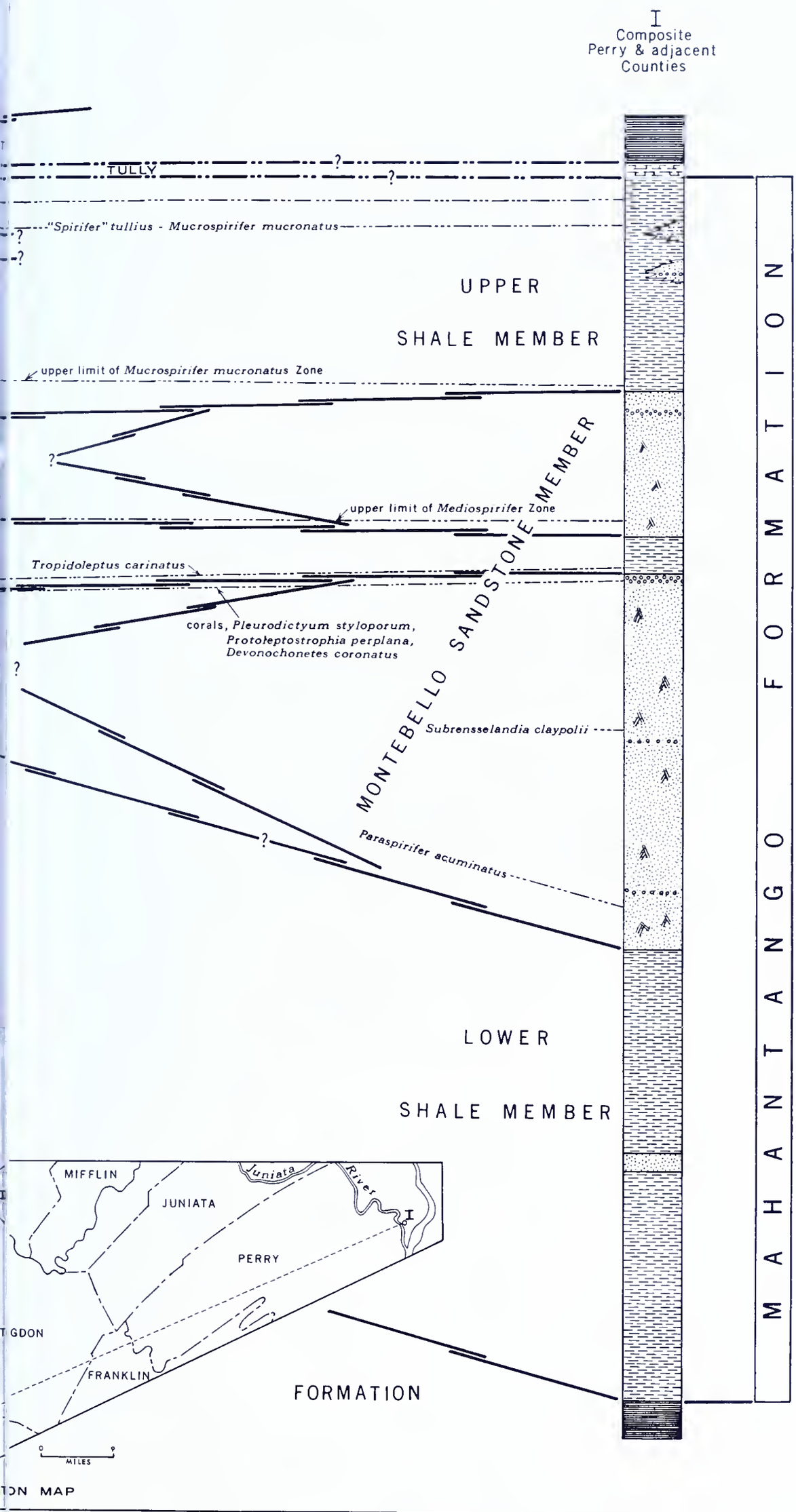


Plate 3. Stratigraphic relationships of the M



hantango Formation in south-central Pennsylvania.